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THE NEBULA IN ANDROMEDA.

PHOTOGRAPHED BY MR. ROBERTS, DEC 30, 1888

Copied from *Himmel und Erde*

THE SIDEREAL [illegible]

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THE SIDEREAL MESSENGER,

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DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, No. 1. JANUARY, 1890. WHOLE No. 81.

THE GREAT NEBULA IN ORION.

WILLIAM H. PICKERING.

For The Messenger.

Since its earliest discovery this object has occupied a prominent place in the literature of astronomy, but it is only within a few years since the recent applications of photography that an adequate means has been found properly to represent its structure. As this object is now in its most favorable position for observation, I take this opportunity to describe some of our more recent results, hoping that others may confirm them the present year.

We have lately photographed the Trapezium, showing all six stars very clearly. Their unequal magnitudes make this a very good test object, and I think that no one should feel that he is getting the best results if his instrument will not show the sixth star well separated, and the fifth, which is decidedly fainter than the sixth, clearly defined. For this class of work an enlarging apparatus should be attached to the telescope.

We have recently considerably extended the nebulosity about θ by giving longer exposures, and using a quicker lens. The connection with c is now well marked, while the long nebulous streak extending southwards from ζ is broadened and joins c upon the other side, connecting the sword handle with the belt. This extension is of much greater area than the other two nebulæ combined. Its northern portion as far as 3° 30′ S is fairly conspicuous, and makes an excellent test object, not of the instrument or the steadiness, but of the clearness of the air, and the blackness of the sky. Owing to the recent advances in stellar photography, this matter of sky illumination has assumed considerable importance, and it is very doubtful if any of the fainter nebulous extensions here described can be photographed at any Observatory lo-

cated in or near a large city. This is due undoubtedly in part to the gas, but chiefly to the electric lights, which illuminate the slight haze found in the sky of nearly all localities with an almost inperceptible light, but which is nevertheless, very destructive to the fainter detail shown by our most sensitive plates when used with long exposures. The difficulty is analagous to the impossibility of photographing the solar corona without an eclipse, or of photographing the zodiacal light during an eclipse.

An interesting structure brought out upon our plates is a large spiral nebula whose outer extremity starts in the vicinity of γ Orionis. It passes about four degrees north of ζ extends to thence to β, then north to η, with an outside stream lying nearly north and south, and preceding β about four degrees. Another stream lying nearly east and west precedes η about the same amount. This nebula is about seventeen degrees in length, by nearly the same breadth, and surrounds a cluster of bright stars including the belt and sword handle. and extending towards γ. The region containing the nebula is noticeably lacking in stars brighter than the eighth magnitude, but contains the very bright stars γ, and β. It is possible that a plate with double our present exposures, which we are soon going to try, will fill the space between η and ζ, thus making the great nebula the inner termination of the spiral. This nebula is shown by three different exposures and is very distinctly marked.

All the above described negatives were taken at our California station upon Wilson's Peak (altitude 6250 feet). Those showing the nebulæ were taken with a Voigtländer portrait lens of 2.6 inches aperture and 8.6 inches equivalent focus, with an exposure of three hours. Stars eleven to the twelfth magnitude are well shown. A more detailed account of these observations with illustrations is in course of preparation, but will probably not appear in time to be of use to observers this year.

Dr. Lewis Swift, director of the Warner Observatory, has discovered another comet. We regret to hear this. The market is overstocked with comets already and there is nothing in our tariff law to prevent their importation and thus bearing the market. How would it do to pension Dr. Swift and put him on the retired list.—*Burlington Hawkeye.*

ON THE STABILITY OF THE RINGS OF SATURN.

PROFESSOR GEORGE W. COAKLEY.

FOR THE MESSENGER.

It is now nearly three hundred years since Galileo caught the first imperfect view of the rings of Saturn; and more than two hundred years since Huyghens made out their complete character as thin broad circular rings surrounding the planet, but detached from him on all sides. The two old rings that thus date back at least some three hundred years, and probably very much longer, appear to be concentric with the planet and, with the exception of some partial divisions in them, they present apparently a continuous surface, like that of the planet itself. It was supposed at first, that they were solid bodies like the planet, in the shape of thin flat circular discs of nearly uniform dimensions on all sides, and suspended concentrically over the planet's equator. They were also soon found to revolve about the planet as his satellites do, and in the same direction.

Before the application of Newton's law of gravitation to the motions of the heavenly bodies, no one knew any reason why these rings might, or might not, thus continue to revolve about the planet for all time, past or future. But La Place first in applying this law to the rings and the planet, found that if the rings were uniform, homogeneous solids, they could not forever revolve concentrically around the planet, except in the absence of all disturbing forces, which might tend in the slightest degree to separate their centers from that of the planet. He showed that they posessed an *unstable equilibrium of revolution* around the center of the planet, which might be maintained for any length of time, if there was nothing to disturb it; but that the attraction of one of the satellites, or of the sun, or of one of the other planets of the solar system, and especially of Jupiter at his nearest approach, would necessarily tend to separate the centers of the rings from that of Saturn. In this case, if the rings were homogeneous solids, of uniform dimensions in all their parts, La Place showed that the mutual attraction of Saturn and of the several parts of the ring would cause their centers to separate more and more, until the nearest portion of the ring should be precipitated violently upon the

body of the planet and the ring would necessarily be shattered by the collision. Moreover this catastrophe would take place in a very short time. As the separation of the centers would proceed with continually accelerated velocity, perhaps a month would be more than enough to ensure the destruction of the rings. But they have endured now for hundreds and very probably for thousands of years. Hence there must be some means of counteracting this destructive effect of all the attractions to which the rings are subject, and of maintaining their *stable equilibrium of motion* about the planet. LaPlace was still disposed to admit the solidity of the rings. But then, notwithstanding appearances and measurements to the contrary, he denied that they could be uniform in dimensions, or in the density of their several parts. He thought that, if the constitution in different parts were such that their centers of gravity were not at the center of Saturn, then these centers of gravity might continue to revolve around that of the planet, in the same manner as a satellite, and that the *stability of equilibrium* of their motion might thus be preserved. This was, however, merely an opinion of LaPlace, but without any demonstration on this particular point.

The subject remained in this condition until between forty and fifty years ago, when Mr. George P. Bond was examining Saturn's rings with the then new and great telescope of the Harvard Observatory. He saw new divisions and openings in the rings which led him to examine the records of older astronomers, to see if they had made similar observations. He found in the observations of European and other astronomers of the preceding half century and later, many records of the markings and changes which he had himself observed, such as temporary divisions in certain parts of the rings, and of their subsequently closing up. From all these observations, including his own, Mr. Bond came to the conclusion that the rings must be of a liquid nature. Moreover, when he compared the mass of the rings as determined by Bessel, with their volume, as obtained from observation, he found that their density was nearly that of water.

This confirmed him in the view that they were probably of a liquid nature. LaPlace also had previously determined

the mean density of the rings to be 1.3 times the density of Saturn. Professor Newcomb gives the mean density of Saturn, compared with water, as 0.75; hence LaPlace's determination will make the density of the rings, compared with water, 0.97½, or only 2½ per cent less than the density of water. In this way Mr. George Bond could account for the temporary openings and closings of certain parts of the rings by the freedom of motion of its several parts under the stress of the varying attractions to which it was subjected by the planet Saturn, and the satellites, and other bodies of the solar system. But this was not all that Mr. Bond did. LaPlace had left his opinion, without demonstration, that the stability of equilibrium of the rings might be maintained if they were *irregular solids*. But Mr. George Bond showed that *no solid ring* could be maintained in stable equilibrium.

On this part of the subject, Professor Newcomb in his Popular Astronomy, has the following statement:

"The question was next taken up in this country by Professors Pierce and Bond. The latter started from the supposed result of observations—that new divisions show themselves from time to time in the ring, and then close up again. He thence inferred that the rings must be fluid, and to confirm this view, he showed the impossibility of even an *irregular solid pair of rings* fulfilling all the necessary conditions of stability and freedom of motion. Professor Pierce taking up the same subject from a mathematical point of view, found that no conceivable form of irregular solid ring would be in a state of stable equilibrium; he therefore adopted Bond's view that the rings were fluid. Following up the investigation, he found that even a fluid ring would not be entirely stable without some external support, and he attributed that support to the attractions of the satellites. But as LaPlace did not demonstrate that irregularities would make the ring stable, so Pierce merely fell back upon the attraction of the satellites as a forlorn hope, but did not demonstrate that the fluid ring would really be stable under the influence of their attraction. Indeed now it seems very doubtful," says Professor Newcomb, "whether this attraction would have the effect supposed by Pierce."

Professor Newcomb makes the following additional statement:

"The next, and, we may say, the last important step was taken by Professor J. Clerk Maxwell, of England, in the Adams prize essay for 1856. He brought forward objections, *which seem unanswerable*, against the solid and fluid ring, and revived a theory by Cassini about the beginning of last century. This astronomer considered the ring to be formed by a cloud of satellites too small to be separately seen in the telescope, and too close together to admit of the intervals between them being visible. This," says Professor Newcomb, "is the view of the constitution of the rings of Saturn now generally adopted."

It is to re-examine this question, and to see if there is not still good reason to maintain the view of Mr. George P. Bond, in preference to that of Cassini and of Professor Maxwell, that this paper has been prepared.

In the first place, it will be readily granted that, if the fluid ring be obliged to preserve an *invariable form*, it will be in no better condition, as to a stable equilibrium, than the *solid* ring, which it is agreed that Mr. Bond, Professor Pierce and Professor Maxwell have all proved to be in *unstable equilibrium*

If Professors Pierce and Maxwell have tacitly assumed an *invariable form* for the fluid ring; or if, with Mr. Bond also, they have failed to find an *adequate cause* for any *required change in its form*, so that its equilibrium may be restored to stability, this fact will account for their want of success in establishing the condition of equilibrium of the rings.

In the present paper it is hoped that this important link in the chain of evidence for the ring's stability will be supplied.

Sir John Herschel, in his Outlines of Astronomy, gives the micrometric measures of the several parts of Saturn's two older rings, which were made by Struve, and reduced to the planet's mean distance from the sun. They are as follows:

Exterior diameter of exterior ring	40″.095
Interior diameter of exterior ring	35 .289
Exterior diameter of interior ring	34″.475
Interior diameter of interior ring	26 .668
Interval between planet and interior ring	4″.339
Interval between the rings	0 .408

Thickness of the rings, not exceeding 250 miles, which is equivalent to 0 00666 of Saturn's equatorial radius.

The thickness of the rings Herschell concluded from their total disappearance in his telescope in 1833, while that telescope would distinctly show a line one-twentieth of a second of arc in breadth. Hence the thickness was less than 0″.05.

Professor Newcomb, in his Table of Elements, on page 528 of his Popular Astronomy, gives the angular diameter of Saturn at distance unity, or at the earth's mean distance from the sun, equal to 162″.8. Hence, at Saturn's mean distance from the sun, his equatorial diameter would be $\frac{162''.8}{9.5388} = 17''.067136$. Therefore Saturn's *equatorial radius*, at his mean distance, is 8″.5336.

If, therefore, we take Saturn's equatorial radius as the unit to measure the distances from his center to the several parts of the two older rings, as well as the distances of his satellites, we shall find the following results:

Distance to outside of exterior ring	2.355
Distance to inside of exterior ring	2.068
Breadth of exterior ring	0.287
Distance to outside of interior ring	2.020
Distance to inside of interior ring	1.563
Breadth of interior ring	0.457
Interval between planet and interior ring	0.059
Interval between the rings	0.048
Thickness of the rings not greater than	0.00666

Professor Newcomb gives a table of distances of Saturn's Satellites in terms of his equatorial radius as a unit, which agrees to the nearest tenth of a unit, in all but two of the satellites, with a similar table given by Sir John Herschel. Professor Newcomb's table, which will here be adopted, is as follows:

1st	Satellite,	Mimas, distance from Saturn	3.3
2d	"	Enceladus, " " "	4.3
3d	"	Tethys, " " "	5.3
4th	"	Dione, " " "	6.8
5th	"	Rhea, " " "	9.5
6th	"	Titan, " " "	20.7
7th	"	Hyperion, " " "	26.8
8th	"	Japetus, " " "	64.4

The effect of Saturn's sixth and largest satellite, Titan, in removing the center of the exterior ring from the center of the planet, may be determined by the same kind of computation as that by which the tides in the waters of the earth are produced. This is done by taking account of the *difference of attraction* which the moon exerts on the earth as a

whole, at its center, and on the waters nearest the moon and farthest from her. For it is evident that the satellite, Titan, will attract the part of the ring nearest to him more strongly than he will attract Saturn's mass condensed at the planet's center; and that he will attract the more distant part of the ring less strongly than he will attract Saturn's mass. Hence the *difference of attraction* by the satellite, with regard to Saturn and the two opposite parts of the ring, will be entirely similar to the action of the moon in producing our tides.

In order to determine the *nature* of these effects, it will not be necessary, perhaps, to develop, in an entirely rigorous form, the whole mathematical theory of the tides; but only to recall a few points in the simplest form of this theory.

Taking the earth's equatorial radius as the unit of distance, the moon's distance from the earth's center may be stated as 60. Its distance from the waters nearest the moon will then be 59; and from the waters farthest from the moon, in the opposite hemisphere, the distance will be 61.

If m = the moon's mass, her accelerative attraction on the earth as a whole is the same as though the earth's mass was all condensed into its center, and will be expressed by $\frac{m}{60^2}$. The moon's attraction on the waters nearest to her will be expressed by $\frac{m}{(59)^2}$; and her attraction on the waters furthest from her by $\frac{m}{(61)^2}$. Hence the waters directly under the moon, and nearest to her are drawn away from the earth's center by the moon's disturbing force f_1,

$$f_1 = \frac{m}{(59)^2} - \frac{m}{(60)^2} = \frac{119m}{(59)^2 \times (60)^2} \text{ or, } f_1 = \frac{m}{105308}.$$

This force tends to diminish the gravitation of the water nearest the moon towards the earth's center, and to cause it to swell upwards towards the moon, and away from the earth's center, or to raise a high tide directly under the moon.

But the *difference* of the *moon's* attraction on the earth, and on the waters farthest from her, in the opposite hemisphere, is

$$f_2 = \frac{m}{(60)^2} - \frac{m}{(61)^2} = \frac{121m}{(60)^2 \times (61)^2} = \frac{m}{110707}.$$

This force, f_2, tends to draw the earth's center away from the most distant waters, or it is equivalent to driving these waters away from the earth's center, and so tends to raise another high tide in this opposite hemisphere.

To obtain the entire momentary effect of the moon in tending to produce these high tides in the opposite hemispheres of the earth, it would be necessary to take account of the sum total of such disturbing forces in each hemisphere caused by the action of the moon on the earth and on each particle of water wherever situated in the two hemispheres. But, as many of these forces in each hemisphere are nearly equal to those we have expressed by f_1 and f_2, and as they gradually approach to equality in proportion as we recede from the points nearest the moon, and most distant from her, it is natural to suppose that at least a certain rough approximation to the ratio of all those forces in the one hemisphere to those in the other, will be obtained by taking the ratio of the single forces, f_1 and f_2. This ratio is

$$\frac{f_1}{f_2} = \frac{110707}{105308} = 1.0512.$$

It follows from this *entirely arithmetical computation* that the *moon's disturbing force* on the waters nearest to her, is about five per cent greater than that which she exerts on the waters most distant from her in the opposite hemisphere. By taking the actual summation of the greater portion of these forces in the two hemispheres, in a manner that will be subsequently given in this paper, I find that the excess of the moon's action on the waters supposed to cover the whole of the nearer hemisphere, over her action on the waters supposed to cover in like manner the more remote hemisphere, is about two per cent of the whole action on the nearest hemisphere. The consequence is that the moon ought to raise a tide in the hemisphere immediately under her about two per cent higher than in the opposite hemisphere at the same time. The average lunar tide in the open ocean, at great distances from the continents, near any small island, has been ascertained not to exceed about two feet. Two per cent of this height is only forty-eight hundredths of an inch, less than half an inch. It is not surprising then that this small difference is not generally recognized. Yet it exists, and a further consequence of it is that the earth's center of gravity is

thereby slightly removed towards the moon, because of the greater bulk of water drawn towards our satellite.

The sun also affects the tides in our oceans, in the same manner as the moon does; but, owing to his much greater distance, or to his much smaller *difference of distance* from the earth's center and from its two opposite hemispheres, compared with his whole distance, his greatest tidal disturbance of the oceans is not more than half that produced by the moon; and the difference of his action in the two hemispheres is very much smaller than that before noticed, though it is of the same kind. Let us next examine the disturbing action of the sun on the exterior ring of Saturn, arising from the *difference of his attraction* on the planet, and on the two halves of the ring situated on opposite sides of Saturn with reference to the sun.

Saturn's mean distance from the sun, in terms of the greatest radius of the exterior ring, taken as the unit, is about 10285. Hence the sun's distances from the nearest and most remote points of that ring are 10284, and 10286.

If therefore f_1 and f_2 are now the disturbing actions of the sun, in reference to these parts of the ring and Saturn's center, and if $M=$ the sun's mass, it follows that

$$f_1 = \frac{M}{(10284)^2} - \frac{M}{(10285)^2} = \frac{20569\,M}{(10284)^2 \times (10285)^2}$$

$$f_2 = \frac{M}{(10285)^2} - \frac{M}{(10286)^2} = \frac{20571\,M}{(10285)^2 \times (10286)}$$

$$\text{Hence } \frac{f_1}{f_2} = \frac{20569}{20571} \times \left\{\frac{10286}{10284}\right\}^2 = 1.00029$$

Hence the sun tends to draw the nearest point of the exterior ring away from Saturn's center by a certain small disturbing force, and to draw away Saturn's center from the farthest point of the ring, or apparently to drive this part of the ring away from Saturn's center, by another small disturbing force. But the former force exceeds the latter by less than three hundredths of one per cent of the former. By taking the sum total of all the principal disturbing forces of the sun on the two opposite parts of the ring, I find the ratio to be $\frac{f_1}{f_2} = 1.000115$, or about one hundredth of one per cent more on the nearer, than on the more remote half of the

ring. The tendency of the sun's disturbing forces is therefore to draw the center of this ring very slightly away from Saturn's center toward the sun. At the same time, *if the ring be liquid*, this action of the sun will tend to produce high tides in the portions of the ring nearest to, and farthest from thc sun. But the former tide will exceed the latter by about *the same one hundredth part of one per cent of the nearest tide.*

The action of the sun on the inner ring will be of the same kind but smaller in amount, because the *difference* of *distance*, upon which it depends, is smaller.

Let us next examine the disturbance of the exterior ring by the planet Jupiter when nearest Saturn. The nearest mean distance of Jupiter from Saturn, in terms of the greatest radius of the exterior ring, is about 4675. Hence, if m = Jupiter's mass, and f_1 and f_2 are respectively the disturbing actions of Jupiter on the nearest and farthest points of the ring, it will follow that,

$$f_1 = \frac{m}{(4674)^2} - \frac{m}{(4675)^2} = \frac{9349m}{(4674)^2 \times (4675)^2}$$

$$\text{and } f_2 = \frac{m}{(4675)^2} - \frac{m}{(4676)^2} = \frac{9351m}{(4675)^2 \times (4676)^2}$$

$$\therefore \frac{f_1}{f_2} = \frac{9349}{9351} \times \left\{\frac{4676}{4674}\right\}^2 = 1.0034.$$

But if we take the sum of all the principal disturbing forces of Jupiter on the two opposite halves of the ring, nearest to him, and farthest from him, then the above ratio will become 1.00025. Hence Jupiter's action on the nearest half of the ring exceeds that on the opposite half, by about one fortieth part of one per cent of the former, when nearest to Saturn. By this amount Jupiter tends to draw away the center of the ring from that of Saturn; and *by the same amount* he tends to produce a greater tide in the nearest half of the ring then in its opposite, *provided the ring be fluid.*

It is unnecessary to take account of the actions of the other planets on the rings, since their action is very much less than that of Jupiter, but necessarily of a similar nature.

TO BE CONTINUED.

ON THE DETERMINATION OF THE BRIGHTNESS OF STARS BY MEANS OF PHOTOGRAPHY.*

EDWARD S. HOLDEN.

Dr. Charlier, assistant in the Observatory at Stockholm, has prepared a memoir† on the use of photography in determinations of the brightness of stars, which has been published by the Astronomical Society of Germany, and dedicated to the Pulkowa Observatory, on the occasion of the fiftieth anniversary of its foundation, August 19, 1889.

The subject treated is so new and so important that it will not be out of place to give a brief review of Dr. Charlier's excellent treatise here and to add some general considerations on the same question. The importance of this subject will be obvious, when we consider that within the next decade we may expect to have at least two sets of photographic maps, covering the whole sky from pole to pole, and including millions of stars down to the fourteenth magnitude.

Besides these systematic maps, hundreds of charts of special regions will be made. Each star on each of these maps will have impressed its image on a negative plate as a disc of measurable size. Hence the magnitude of each and every star *can* be determined, if necessary, and when the catalogue of the stars to the eleventh magnitude, also proposed by the Congress, is constructed, the magnitude of each one of these two million stars *must* be given.

There are two imperative questions to be settled before the principles on which this great work is to be done can be considered to be established. The first and more special question is, What is the relation between the diameter of the photographic image of a star (d) the aperture and focus of the telescope employed (a, f) and the exposure time (t), and what is the relation between the (photographic) brightness of a star and the diameter of its image? Having satisfactorily determined the relations just named, the second and more general question presents itself, namely: On what fundamental principles ought the photographic magnitudes of the stars to be assigned?

* Notes prepared by the staff of Lick Observatory.

† *Ueber die Anwendung der Sternphotographie zu Helligkeitsmessungen der Sterne von C. V. L. Charlier. Publication der Astronomischen Gesellschaft*, XIX. *Leipzig*, 1889, 4to. (pp. viii, 31.)

These two questions are not treated separately in the work before us. Its second paragraph states the problem of the photographic photometry of stars as follows: It is "to determine the function which gives the relation between the size of the photographic image and the photographic brightness of the star, and to determine the constant quantities in this function *in such a manner that the resulting photographic brilliancies shall correspond accurately throughout with the brilliancies determined visually.*"

In my judgment, this is by no means the problem of stellar photographic photometry. It is impossible, in general, to fulfil that portion of the above statement which I have printed in italics. The difference between the photographic and the photometric magnitudes of *Aldebaran*, for example, is more than one and one-half magnitudes, and so with other stars. We may leave this part of the question for the moment, and proceed to give a brief analysis of Dr. Charlier's memoir, laying stress principally on the novel portions of his work.

The observations which he discusses were made with a photographic lens by Steinheil of 3.19 inches aperture and 39.37 inches focus ($\frac{f}{a} = 13$). The plates took in an area of twenty square degrees. The images were satisfactory over a field of about three degrees in diameter. Stars to eighth magnitude, inclusive, left trails. The plates employed were made in Lyons, by Lumière. Four plates are discussed. All were exposed on the *Pleiades*, as follows: No. 2, $t = 13m$; No. 4, $t = 2h$; No. 24, $t = 1h\ 30m$; No. 26, $t = 3h$. The plates were exposed at very different altitudes, and no account is taken of absorption of light by the atmosphere.

Dr. Charlier finds two defects in the plates; first, bright rings round the larger stars, which he proves to be due to reflections from the back of the plate (the well-known halation images); and, again, false stars. He finds no less than fifty-six such false stars on his plate No. 26. They were probably due to defects in the manufacture of the plate itself.

As subjects for experiments he chose the *Pleiades*, because their photometric magnitudes are accurately determined and also because they afford a variety of magnitude within a comparatively small area.

Although he does not expressly mention the fact, the

Pleiades have the special advantage for his purpose of being all of the same spectral type. A region containing many very red or many very blue stars would have given a corresponding number of anomalous results, which are avoided by choosing a group of stars of one type. The diameter of each star on each of the four plates was measured. Calling H the brightness of a star, and m its magnitude and 0.4 the light ratio, Dr. Charlier starts with the formula

(1) . . . . $H = (0.4)m$

That is, he assumes that the brightness of a first magnitude star ($m = 1$) is 0.4. It is better to write this formula, I think,

(2) . . . . $H_m = (0.4)m - 1$

which for $m = 1$ gives $H_1 = 1$. Assuming the equation (1), however, and further assuming that when d is zero, H must be zero, he finds

(3) . . . . $m = a - b \log d$

Here it may be remarked that, in fact, H is not necesarily zero for $d = 0$, because all stars below a certain brightness will fail to produce an image on the plate, no matter how long the exposure may be—for any practical exposure time. The brightness of a star must be above a certain finite limit in order to produce any impression at all. The assumption is sufficiently accurate, however, for the purpose in hand. The relation between exposure-time and diameter of star image is next determined from a series of exposures on *Polaris*, assuming the form

(4) . . . . $d = d_0 . t^k$

That is, that the diameter of the star-image varies as the k^{th} power of the time. From *Polaris* (two plates) the values of k are 0.243 and 0.249; from a star 5th mag. k results 0 243,—hence, the numerical value of the diameter of the star-image varies as the fourth root of the time or

(5) . . . . $d = d_0 \sqrt[4]{t}$

This formula shows that the diameter d will be doubled when the exposure t is increased sixteen-fold.

If there are no limits to the formula it also shows that, for the telescope and plates employed, an exposure of one-sixteenth second would give a preceptible image. Without

considering the question of the *range of sensitiveness* of plates I may state it as my opinion that the formulæ of Dr. Charlier and those of Professor Schaeberle (*Publ. Ast. Soc. Pacific, No. 4*) can (at present) be applied safely only to *over-exposed* stars, and that there is a superior limit also beyond which they are no longer applicable. Both Dr. Charlier and Professor Schaeberle have found that the stars with the longest exposure are best fitted for the determination of magnitude.

We may now quote, without further remark, the final formula to which Dr. Charlier is led, which gives the relation between m (star's magnitude), d (diameter of star-image on plate), and t (exposure time). It is

(6) . . . . $m = A + B \log d + C \log t$

In the particular plates in question the constants A, B and C are

$$A = +17.2 \qquad B = -6.75 \qquad C = +1.69$$

A, B and C are proved to be constant on the four plates in question; t is expressed in minutes.

From the formula (6) the photographic magnitudes of 52 of the brighter stars in the Pleiades werecomputed and compared with the photometric magnitudes of the same stars as determined by Dr. Lindemann, at Pulkowa. (Table III.)

The mean difference between the photographic and photometric magnitudes is ± 0.22 mag. The differences occur 0.6 mag. (twice), 0.5 (twice), 0.4 (four times), 0.3 (twelve times), 0.2 (twelve times), 0.1 (ten times), 0.0 (seven times). Two stars are either variable or red. The individual results for the photographic magnitudes from the four plates agree well. The mean difference is 0.10 mag. The largest difference is 0.4 (occurring twice).

Dr. Charlier makes the important remark that the red stars, etc., which are thus discovered in the group of the Pleiades, are very suitable for a determination of its parallax, since they differ in spectral type, and are therefore *presumably* not members of the group. A few moments' examination with a small spectroscope will, however, be a surer indication in similar cases.

Section III of the memoir is devoted to a comparison of the results of the Stockholm photographs with those ob-

tained by Professor Pickering, at Harvard College, and by Dr. Scheiner, at Potsdam. The linear formula deduced by the latter is shown to be inferior to the logarithmic form adopted by Dr. Charlier; and in Table IX it is shown that the systematic differences between the results at Harvard College and at Stockholm are likely to be due to constant errors in the H. C. O. results. In all this discussion, as has been said, the effect of atmospheric absorption is omitted, as it has been in all previous publications of the kind. It is of considerable amount, however.

Section IV of the memoir is chiefly concerned with a comparison between the photometric magnitudes given by Wolf, of Paris, for 571 of the *Pleiades* stars and the photographic magnitudes of the same stars derived from one plate (only) taken at Stockholm. Twenty-eight of Wolf's stars do not appear on this plate; *en revanche*, it contains more than 100 stars not in Wolf's catalogue. In passing, we may remark that the single Stockholm plate made in three hours has a value at least comparable with the chart of M. Wolf, which was the result of many months of labor. It is worth while to remark here that it is highly desirable for the present to make every result derived by photography depend on two negatives at the very least. A comparison of the scales of Wolf and Charlier closes this section and concludes the important work.

We may now say that the present memoir and that of Professor Schaeberle, previously cited, have fixed the form under which discussions of this character must be made in future. For every telescope a relation between the diameter of a star image and the corresponding exposure must be deduced in the form $d = \varphi\,(\log t)$

The constants of this formula will vary with the aperture, focus, plate, site, and with the spectral type of the star, and will probably be applicable only within certain limits of absolute brightness and within certain limits of exposure time.

The memoir of M. Charlier is an excellent example of the method of discussion which must be adopted to determine this function for all cases where the prime object is to make the photographic magnitudes harmonize as nearly as possible with the photometric. The real fundamental question is, however, Should any endeavor be made to harmonize them?

I proceed to discuss this point as briefly as possible, in the light of our present knowledge, since it is the most important question remaining open for settlement.

Establishment of the Present System of Visual Magnitudes.

Let us consider, very briefly, the history of the introduction of the present system of visual magnitudes. The main epochs in this history are very few. The first is that of Ptolemy (A. D. 150,) who arbitrarily assumed the brightest stars to be of the *first*, the faintest which he could see, to be of the *sixth* magnitude. The other stars were divided into classes of 2d, 3d, 4th, 5th, etc., magnitudes. The second great event in this history is the publication of the *Uranometria Nova* by Argelander, in 1843. He adopted the general rules laid down by Ptolemy, and followed by Sufi, Tycho and Bayer. The brightest stars were called first magnitude, the faintest visible to the naked eye were called sixth magnitude. Stars of the classes 2, 3, 4, 5, etc., were intermediate. By Fechner's law, it necessarily followed that equal differences of sensation corresponded to equal *ratios* of light; or that the light of a star of m^{th} magnitude must be $\frac{1}{\delta}$-th part of the light of a star one magnitude brighter $(m-1)$. Measures of this *light ratio* δ show its numerical value to be 0.4 very nearly, omitting all questions of small variations, etc.

The *Durchmusterungen* of Argelander, Krueger, Schoenfeld and Thome will determine the visual magnitude of every star in both hemispheres as bright as the tenth magnitude by this same scale. That is, if the brightness of a star of the first magnitude is unity, the brightness of a star of the m^{th} magnitude is

(7) . . . . $H_m = (\delta)^{m-1}$ where $\delta = 0.4$

The universal practice of modern observers has extended this scale from the tenth down to the sixteenth or seventeenth magnitude (the faintest stars now visible in the largest telescopes). Thus the *accidental* choice of the sixth magnitude as the limit of the naked-eye stars by Ptolemy has fixed the light-ratio and the practice of all astronomers with regard to visual magnitudes for all time to come. It is to be noted that if Ptolemy's work on visual magnitudes were to be done again *de novo*, and absolutely independently, the

method chosen would be essentially the following: *One* standard star would be chosen (Polaris in our hemisphere). This star would be compared with a selected group of stars, and the fact of the constancy (or the law of the variation) of its light during the course of the observations would be established. Every other star would be compared with Polaris, either directly or indirectly, and its relative light determined. Some convenient magnitude would be arbitrarily assigned to Polaris, and some convenient, light-ratio would be *arbitrarily* assumed. The magnitude of any and every star would then be deduced from the measured ratio of its brightness to that of *Polaris* by a formula like our (7) in which the numerical value of δ would be assigned on grounds of convenience alone. It is very likely that the value $\delta = 0.4$ would be again chosen because the tenth part of a magnitude (easily written with one place of decimals), thus defined, is about the limit of the reception of the most highly trained human eye.

Such, I conceive, would be the process adopted if the whole question of visual magnitudes was entirely open, and if a Congress of Astronomers were called in 1890 to decide on the proper methods to be followed in fixing the visual magnitudes of the stars anew or for the first time. The process is simple; it is complete: it is logical; it is sufficiently accurate for all conceivable uses to which visual magnitudes are to be put. The use of a visual magnitude assigned to a star is chiefly to determine its brightness at one epoch, so that observations at other epochs will determine whether there have or have not been changes in its light. It is from celestial bodies which are subject to change, and chiefly from these, that we can hope to learn anything of the nature of celestial bodies in general. A secondary convenience in having a magnitude assigned to a star is to aid in identifying, classifying and describing it.

Establishment of a System for Determining Photographic Magnitudes.

The International Congress of Astronomers will have to decide the question as to how to define the photographic magnitude of a star. They will soon be in possession of plates on which millions and millions of stars have im-

pressed themselves. The diameter of each one of these stars can be measured. The photographic brightness of each one of these stars relative to the photographic brightness of Polaris (for example) can be readily determined. What *magnitude* shall be assigned to one of these stars? Dr. Charlier's answer to this question has already been given. He would assign to each one of a group of stars a photographic magnitude, deduced on the principle that the mean deviation of their photographic magnitudes from their visual magnitudes should be as small as possible. If the same star occurs in two or more different groups, it will certainly have different magnitudes assigned to it, according as one or the other set of standards is employed. The same method has been followed by Mr. Espin and by the Harvard College Observatory in all of its many important publications on this question, notwithstanding the fact that (owing to the color of a star) the photographic and visual magnitudes not infrequently differ by at least *two whole magnitudes*. That is, if the visual brightness be expressed by 1.00, the photographic brightness of the same star may be no more than 0.16, or only one-sixth part. Such anomalies must, in the nature of things, constantly appear for a considerable percentage of the stars. A tolerable agreement is possible for perhaps eighty per cent of the larger stars, and even here there will be small persistent differences. For those remaining, the disagreement will be more or less marked, according as the spectral type of the star in question varies more or less from the average type. The reason of this is well known. The eye is sensitive to rays which fall between the Fraunhofer lines B and G (approximately) of the solar spectrum. The maximum brilliancy to the eye is somewhere near the line *b*. The photographic plate is sensitive to rays falling between F and N of the solar spectrum (approximately). The plates now in use are sensitive in the highest degree to rays of about the wave length of the line G.

Whenever we have a group of say 500 stars, whose spectra are nearly all of the same type (as the Pleiades, for example,) we can measure for each star the relative energy of the light in the portion of its spectrum between B and G (by the eye), in that between F and N (by the photographic plate), and, *as the energy is distributed according to*

the same law in the spectrum of each star of the group, we can determine constants of reduction which *will* make the photographic magnitudes of the various stars agree well with their visual magnitudes. If, however, two hundred of the stars are very red, one hundred very blue, and two hundred of the ordinary type, it is, in the nature of things, impossible to bring the photographic and the visual magnitudes to a good agreement. The very red stars will always appear brighter to the eye than they do on the plate, and the very blue stars will always appear fainter to the eye than on the plate, and there is no process of reduction which will smooth away a difference in their magnitudes which is inherent in their nature. If there were such a process, it would be most unwise to employ it. When I see that a star is of the visual magnitude 1 and the photographic magnitude 2.5, I at once learn something of the nature of this star's spectrum, and so in like cases.

It therefore seems to be a rational and useful plan to leave out all consideration of the visual magnitude of stars in determining their photographic magnitudes. A simple and most satisfactory method of procedure would be to assume Polaris as the standard star of the whole sky, and to fix its magnitude (when in the zenith of a station at sea level) at 2.00, once for all; to select a set of secondary standards, distributed around the equator, and to determine the brightness of each one of these stars in terms of that of Polaris (a proof of the constancy of the light of Polaris being thus attained). Important groups like the Pleiades, etc., would also have their brightness determined in terms of that of the standard. The brightness of the principal Southern stars should also be fixed in terms of Polaris indirectly through the Pleiades, etc. A light ratio should be selected on grounds of convenience alone and the photographic magnitude of every star should be determined by an equation like our equation (7) in terms of a single standard star with a definite light ratio.

If this program were to be followed, we should simply have to add to our star catalogues another column headed "Photographic Magnitude," which would immediately follow the column "Visual Magnitude." The agreement or disagreement of the two numbers would tell us something of

the nature of the spectrum of each star. In order to have the work exact, it would be necessary that all the stars should be photographed on one kind of plates, as is now done by the Harvard College Observatory, and as will be done by the International Photographic Congress. The photographic Southern Durchmusterung might for convenience have its magnitudes expressed in visual units, though the DM of the Cordoba Observatory will make this unnecessary, and will, in fact, make it distinctly to the advantage of science if the photographic DM is made entirely photographic. The International map of two million stars to the eleventh magnitude should, in my judgment, give photographic magnitudes alone. I can conceive of no advantage to be gained by determining the approximate visual magnitudes of these millions of stars at all comparable with the labor involved. In any event, it would seem that the photographic magnitudes should be given whether the visual magnitudes are or are not.

Such, it appears to me, are the general principles which should govern in the determination of star magnitudes by photography. I have set them forth because no amount of discussion at this stage can be called superfluous. After the International Congress has once settled its methods of procedure, it will be the duty of all coöperating Observatories to conform to the spirit and to the letter of the methods finally adopted. As long as they are not yet adopted any suggestions, however simple, cannot fail to be of use.

The Lick Observatory is endeavoring to make a modest contribution to the general subject of which we have spoken. Professor Schaeberle has made observations at Mount Hamilton (4209 feet above sea), and will make observations at Cayenne, South America, (nearly at sea level), to determine the photographic atmospheric absorption at zenith distances between 0° and 70° or 75°. He has already compared the Pleiades and other stars with Polaris, and will compare the principal southern stars with the Pleiades, etc. In this way, his observations, if successful, will enable us to transfer the standards of the Northern Hemisphere into the Southern.

The immense work now in progress in both hemispheres under the auspices of the Harvard College Observatory will

afford material for a thorough discussion of the whole subject. The contributions of Dr. Charlier and Professor Schaeberle have established the final form under which special discussions of this kind must be made. The only part of the subject remaining for settlement is that which relates to the establishment of the fundamental principles on which the final methods of reductions are to be based. I have endeavored, in what precedes, to set forth what seems to me to be a satisfactory system, at once simple and comprehensive.—*From advance sheets of Publications of the Astronomical Society of the Pacific.*

ON THE LIMIT OF SOLAR AND STELLAR LIGHT IN THE ULTRA-VIOLET PART OF THE SPECTRUM.*

WILLIAM HUGGINS, D. C. L., LL. D., F. R. S.

It has been long known that the solar spectrum stops abruptly, but not quite suddenly, at the ultra-violet end, and much sooner than the spectra of many terrestrial sources of light. The observations of Cornu, of Hartley, and, quite recently, of Liveing and Dewar, appear to show that the definite absorption to which the very rapid extinction of the solar spectrum is due, has its seat in the earth's atmosphere, and not in that of the sun; and that, consequently, all ex-terrestrial light should be cut off at the same place in the spectrum.

During several years I have attempted to obtain the limit in the ultra-violet for stellar light here, but as it was necessary to make use of a bright star at a high altitude, and at a time when the atmosphere was very clear, it was not until September 20th, 1888, that I was able to obtain a result which seemed to me to be satisfactory.

On that night three successive photographs of Vega,† with increasing exposures, were taken on the same plate. The first spectrum was exposed for 10 minutes, the second for 20 minutes, and the third spectrum nearly four times as long, namely, for 70 minutes.

A comparison of the extent of the second spectrum due to an exposure of 20 minutes with that of the third spec-

* Read before the Royal Astronomical Society.
† We are sorry that our engraver is unable to reproduce the fine engraving that should acompany this article.—Ed

trum, to which an exposure of 70 minutes was given, leaves no doubt that the latter spectrum has reached the limit imposed by atmospheric absorption, and has not stopped in consequence of an insufficient exposure of the plate.

The original plate has been enlarged about four times; and a spectrum of magnesium and calcium, taken with the same apparatus, and enlarged simultaneously with the plate of stellar spectra, has been placed above to serve as a scale.

As the spectra are prismatic it is not possible to indicate the wave-lengths in a scale of equal parts. A short scale only is placed over the spectrum where the light of Vega ends.

The spectroscope with which the spectra were taken is furnished with a prism of Iceland spar and lenses of rock crystal, and a mirror of speculum metal was used to condense the light of Vega upon the slit.

It will be seen that at my Observatory* the light of Vega at about λ 3000 is abruptly weakened, and then continues as a very faint line to the point of apparent extinction at λ 2970.

Numerous solar spectra taken here during the last four years with the same spectroscope show an average abrupt weakening at about λ 3000, and an apparent total extinction at about λ 2985.

On two occasions only the very faint weakened spectrum could be traced as far as λ 2970.

The abrupt narrowing of the spectrum at the end towards the red is produced by the rapid falling off of sensitiveness of the silver bromide for light of increasing wave-length.

The increase of breadth of the spectra with increase of duration of exposure is due to the same causes, optical and photographic, which produce the increase of diameter of stellar disks on the photographic plate with longer exposures, when a reflector is used. At *h* the breadths of the spectra, having 20 minutes and 70 minutes exposure respectively, are 0.06 inch and 0.105 inch.†

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* Elevation of the Observatory 177 feet above mean sea level. Barometer about 30.03 inches at the time of observation.

† The law of increase of size of image with exposure is not as yet accurately defined. Bond found that the diameter of star-disks varied nearly as the square root of the time of exposure. Pritchard, using a reflector, found a law near the fourth root; and Mr. H. H. Turner has recently found a law very near the cube root for plates taken with a photoheliograph object glass ('Astron. Soc. Month. Not.,' vol 49, p. 292).

In 1879 Cornu* made experiments on the limit of the spectrum with reference to the altitude of the place of observation. On the Riffelberg, at an elevation of 8414 feet, the spectrum reached to λ 2932, while at the lower elevation of Viège, 2163 feet, the spectrum stopped at 2954. He concludes that the absorption is due to the gaseous constituents, and not to aqueous vapor in the atmosphere.

In 1881† Heartley stated that an amount of ozone proportional to the average quantity in a vertical column of the atmosphere, caused an absorption similar to that observed in the solar spectrum, namely, terminating about λ 2950.

Quite recently Liveing and Dewar have made some important experiments on the absorption-spectrum of large masses of oxygen under pressure.‡ They state that with a tube 165 cm. long and a pressure of 85 atmos., oxygen appeared to be quite transparent for violet and ultra-violet rays up to about λ 2745. From that point the light gradually diminished, and beyond λ 2664 appeared to be wholly absorbed.

In some later experiments with a steel tube 18 metres long and a pressure of 90 atmos., oxygen produced complete absorption above P, *i. e.*, λ 3359.2.

M. Janssen, from his observations on the Alps, concludes that both the bands which follow the law of the square of the density, and the dark lines obeying a different law of information, which are due to oxygen in the solar spectrum, are produced exclusively by the earth's atmosphere—" L'atmosphère solaire n'intervient pas dans le phénomène."§

THE ASTRONOMICAL SOCIETY OF THE PACIFIC—A HANDSOME GIFT.

A meeting of the Astronomical Society of the Pacific was held November 30, at the hall of the Academy of Sciences, corner of Dupont and California streets. In the absence of President E. S. Holden, William M. Pierson occupied the chair. Every seat in the large hall was occupied. The fol-

* "Sur l'Absorption Atmospherique des Radiations Ultra-violettes," 'Journ. de Physique,' vol. 10, 1881.
† "On the Absorption Spectrum of Ozone, and on the absorption of solar rays by Atmospheric Ozene," 'Chem. Soc. Journ.,' vol. 39, 1881, pp. 57, 111-129.
‡ 'Chemical News,' vol 58, p. 163, and 'Phil. Mag.,' September, 1888, pp. 286—290.
§ 'Comptes Rendus,' vol. 107, p. 677.

lowing named candidates were elected members of the society:

O. C. Hastings; Charles M. Bakewell; Warren Olney; Frank James; Dr. J. H. C. Bonte; Hon. Horace Davis; William G. Raymond; James R. Remberton; Augustus F. Knudson; C. D. Perrine; F. B. Rodolf; Miss Agnes Clerke, of London, England; Garrett P. Serviss, Brooklyn, N. Y.; Miss C. W. Bruce, N. Y. City; John Gamble; Charles S. Aikin; Charles F. Hart; J. J. Herr; Whitney Herr; John H. Yoell; N. E. Beckwith; J. E. Richards; Irving M. Scott; Warren B. E. West; Martha McColeman Ewer.

The principal paper of the evening was read by E. E. Barnard, Lick Observatory, on some photographs of the Milky-Way and other celestial objects, that he had made with a large potrait lens of six inches aperture and thirty-one inches focus, strapped to the tube of the six and one-half inch equatorial of the Lick Observatory, the clock-work of the instrument being controlled by hand, with the slow motion rods at the eye-end. A star was kept bisected by the cross wires in a high power eye-piece on the telescope itself. The additional weight of the camera made it necessary constantly to correct the clock throughout the exposures. With this instrument a negative of the Pleiades was made August 23, of this year, with an exposure of 1*h* 15*m*. This showed the Merope nebula conspicuously, the sharp prong of nebulosity from Electra, and some of the nebulosity about Maia and Alcyone. A negative of the Milky-Way (right ascension, 17*h* 57*m*, declination south 18°.9), was made July 28, with an exposure of 2*h* 35*m*; another in the region about M 11 on August 2, with exposure 2*h* 45*m*, and another of the Milky-Way (right ascension 17*h* 56*m*, declination, south 28°), August 1, with an exposure of 3*h* 7*m*, and a negative of the great nebula of Andromeda, August 26, with 4*h* 18*m* exposure. The paper was illustrated by lantern slides from these plates projected on a large screen by the aid of oxy-hydrogen light. The nebulosity of the Pleiades was very conspicuous, and the beautiful cloud forms of the Milky-Way, with the myriads of stars that they were partly resolved into were strikingly fine. The slide of the great nebula of Andromeda, when first projected on the screen, had a mask over it, with a small hole, representing (to scale) the largest field of the great telescope on Mount Hamilton. This was moved about over the slide showing successive fields of view, upon and around the great nebula, indicating

what could be seen at once in the great telescope; the mask was then suddenly removed and the entire nebula, suspended amidst countless stars, flashed into view. The contrast between the limited space representing the field of the great telescope and the sky as shown by the photographic lens was astonishing in the extreme. This slide shows the great rings of nebulosity that were first proved to exist by Mr. Roberts, of England. By carefully counting areas, Mr. Barnard estimated that on the original plate (8 × 10 inches) there were distinctly visible no less than sixty-four thousand stars. This entire plate had been reduced to a lantern slide which, upon the screen, brought out peculiarities in the arrangements of the stars that were not even suspected in the original plate. On all these plates the star images were perfectly round.

Mr. A. O. Leuschner also read a paper on the orbit of Swift's comet which he had computed from observations by Mr. Barnard at the Lick Observatory Nov. 20, 21, and 22. He called attention to the small inclination, and to the small perihelion distance which were suggestive of periodicity.

Elements of the comet of Swift (Nov. 16, 1889) by A. O. Leuschner:

$$\begin{aligned}
T &= 1889 \text{ Dec. } 11.8493 \\
\Omega &= 306^\circ\ 25' \\
\omega &= 116\ \ 24 \\
i &= \ \ 6\ \ 47 \\
\log q &= 0.0633 \\
q &= 1.1568 \\
&\text{o} - \text{c} \\
\delta\lambda \cos \beta &= +\ 1'.2 \\
\delta\beta\ \ &= \pm\ 0'.0
\end{aligned}$$

A paper was read by Mr. A. O. Leuschner "On the Determination of the Relation between the Exposure Time and the Consequent Blackening of the Photographic Film." This paper dealt with the investigation of a plate upon which a number of standard squares had been impressed with the standard lamp of the Lick Observatory. These squares had been given exposures of 1*s*, 2*s*, 4*s*, 8*s*, . . . 128*s*. These squares were then compared with each other and with a standard square by means of the wheel photometer of the Lick Observatory. Every precaution was taken to eliminate

errors of observation in the comparisons. An extended series of observations showed that the density was proportional to the time only between the exposures from 2s to 8s, and with an approximation up to 64s; beyond this the density was not proportional to the time. Mr. Leuschner also found that squares of the same exposure time on different parts of the same plate were not equal in density, due, doubtless to the unequal distribution of the emulsion on the plate, and therefore the above results were derived from comparisons with the deduced mean of four squares in each case.

After the papers were read, the chairman surprised the society by stating an offer from one of the members, Alexander Montgomery, Esq., of a present of $2,500. The donation may be used by the society for any purpose, and it has been suggested that it be used for establishing a gold medal to be given annually for the best paper on astronomy to be read before the society. Mr. Montgomery was accorded the hearty thanks of the society.

Including the members elected at this meeting, the society has now 171 active and life members. Its financial condition is also very satisfactory.

NEWS FROM THE NEBULÆ.

PROFESSOR C. A. YOUNG.

On looking over an article on the nebulæ which I wrote for the *Boston Journal of Chemistry* in 1873, I find nothing to change, although there is now something to add. In the first place, several hundred new nebulæ have been discovered within the sixteen years, so that the total number known is at present well above 8,000. The new ones are, of course, for the most part, extremely faint, and some of the most interesting of them are quite *invisible*, even in the largest telescopes,—*i. e.*, the *eye* cannot detect them: but they impress themselves upon the photographic plate, and so come to our knowledge. For instance, within a small area of about ten square degrees, in and near the constellation of Orion, Professor Pickering has found upon his star-plates twelve new nebulæ, where eighteen were catalogued before; and in the

cluster of the Pleiades, where a single faint nebula was known in 1873, the photographs show wisps of nebula attached to nearly all the larger stars, with a considerable number of smaller nebulæ that are isolated.

When one *looks* through a telescope, very little is gained by prolonging the gaze, but upon the photographic plate the action of light accumulates with the time. By merely lengthening the exposure (in some cases for several hours) an eight-inch glass can be made to bring out objects which the eye cannot reach even with an eighteen-inch instrument.

The gain from photography is by no means only, or even chiefly, in the number of new objects; still more important are the new features which the photograph reveals in certain familiar objects which, after long study in the old-fashioned way, were supposed to be fairly known.

The first photograph of a nebula was made by Dr. Henry Draper of New York, in September, 1880. His very first picture (of the nebula of Orion) was by no means poor: but he soon surpassed it, and in March, 1882 a few months before his untimely death, he produced one which is not much inferior to the best we now have. Within the last two or three years, Common and Roberts in England, and Von Gothard in Hungary, have specially distinguished themselves in this line of work. The photographs of the nebula of Orion which Mr. Common has already made with his three foot reflector, are simply magnificent, and it is to be expected that with his new five-foot instrument, now just beginning its serious work, still more remarkable results will be attained.

Mr. Roberts' photograph of the nebula of Andromeda* is not only admirable as a picture, but it has brought out certain new and most interesting facts, which throw a flood of light upon the structure and nature of the wonderful object. Years ago, Mr. Bond, of Cambridge, discovered in this nebula two narrow dark streaks, or "lanes," nearly straight and paralled to its length,—for the form of the nebula is that of an elongated and pretty regular oval, much brighter at the centre. In the new photograph, these "lanes" are seen to be merely the more conspicuous portions of two narrow, oval, dark streaks, or channels, which entirely surround the central mass, and irresistibly suggest

* See frontispiece copied from "Himmel und Erde."

structure like that of Saturn encircled by his rings—an almost perfect exemplification of Laplace's nebular hypothesis. One eminent astronomer, indeed, has gone so far as to suggest that the two small companion nebulæ, which lie one on each side of the main nebula and outside the lanes, are really two half-finished planets. It is worth noting that the photograph shows no trace of the "new star" which in 1885 so suddenly appeared in this nebula, near its nueleus, and then slowly faded away. The fact that the star is not visible upon the plate does not, however, demonstrate its absence; its invisibility may be due simply to the fact that the region of the nebula in which the star is situated is so bright, that the long exposure necessary to bring out the fainter details has greatly overdone this portion of the plate.

One of the most serious objections to astronomical photography lies precisely here: the retina possesses a far greater range of sensibility than the plate. When we look at a nebula, we can see at the same time its brighter and its fainter regions, as well as the glittering stars which here and there are scattered through it. The highest beauty of the nebula of Orion, for instance, lies in the contrasts and gradations between the splendid stars of the "trapezium," the curdled clouds of greenish light which envelope them, and the impressive blackness of the "fish mouth." In the best photographs of this nebula, the stars are mere blotches, and the contrasted darkness of the telescopic background is replaced by a tangle of faint nebulous wisps, which, though in themselves curious and interesting, none the less obscure and befog the familiar outlines.

The photographs produced by Von Gothard (of Hereny in Hungary), about two years ago, have excited much interest, because they were made with a silver-on-glass reflector of only ten inches aperture. Though the pictures are almost microscopic in size,—only a few millimetres in diameter,—they show many things that before had been clearly seen only with the largest telescopes; and they not only show them, but bring them out with increased emphasis and clearness. The so-called "whirlpool nebula" is an example. The photograph does not exhibit, to be sure, such a series of regular spirals, nor such a blaze of light, as the well-

known drawing of Lord Rosse (which, however, lays no claim to minute accuracy); but on the little photograph every real wisp of nebula appears in its true place, and there are numerous "knots," not shown in the old drawing, where the nebulous matter seems to be gathering into globes, besides many streams of minute stars which stand in evident relation to neighboring filaments of the nebula. These stellar streams form a marked feature in nearly all the photographs of the more brilliant nebulæ. They appear to be formed by the collection of the nebulous matter into isolated masses that are denser and more luminous than the rest. Whether this view is correct or not, the star streams are certainly significant.

Mr. Huggins' recent photographs of the spectrum of the nebula of Orion indicate the same thing in a different way. In one of his observations the slit of the instrument was so adjusted that the image of one of the stars of the "trapezium" fell upon it. As a result, the spectrum, as photographed, showed several groups of bright lines, which cross the star-spectrum and extend out into the nebula-spectrum on each side. This is just what should happen if these "stars" in the nebula are balls of the nebulous matter condensed to a certain degree, but not quite to the state of ordinary stars, which show no bright lines in their spectrum.

As our readers doubtless remember, Mr. Huggins was the first to observe visually the spectrum of a nebula (in 1864), and the first to get a photographic impression of such a spectrum (in 1881). His latest observations have been visual as well as photographic, and have been made specially to test Mr. Lockyer's attempted explanation of the origin of the principal bright lines in the nebula-spectrum. The brightest of these lines, when first discovered, was for a time, attributed to *nitrogen*; but it soon appeared that this identification is untenable. The principal lines of hydrogen are unquestionably present, but this bright green line, which is far more conspicuous than any of the others, has thus far remained a mystery. Very recently, Mr. Lockyer, in connection with his "meteoric hypothesis," (in which he attempts to explain most of the phenomena of the heavenly bodies by the assumption that they are all mere swarms of such meteoric stones as fall upon the earth now and then), has

maintained that this line in the spectrum of the nebula is simply the remnant of one of the *bands* in the spectrum of *magnesium*—a metal which is commonly found in aerolites. The elaborate investigation of Dr. and Mrs. Huggins, who worked together in the observations, is conclusive in proving that this is an error; the mystery remains unsolved.

We must not close our sketch of recent progress without referring to Professor Holden's telescopic observations at the Lick Observatory. In the case of the numerous nebulæ which are not, like the majority, mere oval balls of shining cloud, but are irregular in form, and composed of numerous filaments surrounded by an envelope of fainter light, he finds that the apparent shape of the filament which forms the core of the structure can be explained by supposing it to be in reality a sort of "helicoid" or cork-screw spiral, seen under a special angle. A wire bent into such a helicoid, and looked at from different points of view, presents a great variety of outlines, which very accurately represent the otherwise inexplicable forms of these irregular nebulæ.

As is obvious from what has been said, the main conclusions which had been arrived at sixteen years ago are all confirmed. It is clearer than ever that the nebulæ are not "distant galaxies" far beyond the stars. They are not clusters of full-sized stars, which appear nebulous only because of their inconceivable remoteness, but they are *clouds*, and their luminosity is due to shining gases, among which hydrogen is present, though the gas which furnishes the brightest light remains still unknown. Moreover, these clouds, whatever else they may contain besides the luminous gases, are somehow kindred to the stars, and associated with them in such a way as to suggest almost irresistibly that the nebula is the material out of which stars are made. The question of their permanence remains unsettled. It is altogether probable that processes are going on within them which slowly alter their conditions, but time alone can determine the rate and nature of such changes; the evidence, as yet, is indecisive.—*Popular Science News.*

PRINCETON, N. J., Oct. 31, 1889.

SCIENCE AT THE EIFFEL TOWER.

The great tower, 1,000 feet high, proves to have been one of the most successful features of the Paris Fxposition. The whole of the money paid out for its erection has been re-

turned to the share-holders, and the directors have in hand a clear surplus of about $300,000 after paying all the costs attending its exhibition. As a mere curiosity it will probably pay current expenses for many years to come, and be a boon to the poor of the city, as one-tenth part of the receipts are turned over to the poor fund. Now it is looming up as a valuable aid to scientific investigation, with a possibility that its contributions in that direction will compare favorably with its pecuniary success. A series of meteorological observations, extended through a period of 101 days, shows that the velocity of the wind averages fully three times as great at the top of the tower as at a station situated 1,650 feet away and 69 feet above the level of its base. No great storm occurred during the period of observation, so that the maximum movement is not yet ascertained, but it is found that at the top there is always a fairly strong breeze, the average daily velocity of which is 23 to 33 feet per second. It may be inferred from this that the air at a great distance above the surface of the earth is continually in rapid motion, and that the stillness often experienced lower down is due to friction of the air waves against land or water, which has always a retarding effect. The influence of these superior movements in diffusing and distributing noxious gases and vapors that have more gradually ascended from the surface must be of inestimable value, as undoubtedly to it is due the comparative freedom of man from contagion in spite of his general disregard of sanitary conditions to an extent which would otherwise be suicidal. It is also legitimate to infer that this air movement is a protection against injury from without by scattering and thus rendering innocuous the many masses of gaseous and meteoric matter which the scientists tell us enter the earth's atmosphere each year from the regions of inter-planetary space.

The anemometer is far from being the only instrument that has been made to take observations at the top of the Eiffel Tower. Automatic registers of varying electrical intensity are already being compared, with the promise of valuable results, and the spectroscope has told something of the difference in the apparent quality of the solar light, which is caused by the passage through those atmospheric strata, that are laden with dust and water vapor taken up from the surface. It is probable that even more attention will be paid to these and kindred researches now that the rush of Exposition visitors is over, and it is not too much to hope that the consequence will be a material extension of our knowledge of the physics of our own globe, and perhaps of those of some other worlds.—*Chicago Tribune* (Dec. 18, 1889).

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at greatest elongation east from the sun, 18° 51', on the evening of Jan. 13, setting then an hour and thirty-three minutes later than the sun. For a few days it will be visible to the naked eye after sunset, near the southwest point of the horizon. There are no bright stars in that part of the sky, so that if, between 5 and 6 P. M. from Jan. 10 to 16, one sees a bright star near the southwest horizon he may be pretty sure that it is the planet Mercury. Later in the month Mercury will recede towards the sun, coming to inferior conjunction Jan. 29, and toward the middle of February will become visible in the morning.

Venus is "morning star," but not in favorable position for observation. She is passing around the sun and will be at superior conjunction Feb. 18.

Mars is coming into better position for morning observation. He passes, this month, out of the constellation Virgo into Libra, the Balance. Jan. 24 Mars will be 1° north of the bright star Alpha Libræ, and a little later will be in line with Alpha and Beta between the two. Mars will be the brightest of the three objects and may also be distinguished by his ruddy color. Mars will be at quadrature, *i. e.* 90° from the sun, Feb. 9. He is approaching the earth rapidly, and at the coming opposition, June 4, will be nearer than he has been since 1879. Every opportunity should be utilized to study the "canals," and this study should be begun as early as possible, in order to detect possible changes with the seasons of Mars. In the December number of *L'Astronomie* Ferdinand Meisel, an astronomer at Halle, attempts to explain the duplication of the canals as an optical phenomenon. He regards the canals as possibly actual wide water courses, over which transparent vapors accumulate in the form of cylindrical or semi-cylindrical lenses, refracting the rays which come to us, so that under certain conditions one, two, and even three separate images of the same canal may reach the earth.

Jupiter will be in conjunction with the sun Jan. 9, so that no observations can be obtained this month. At the last meeting of the Royal Astronomical Society considerable time was occupied in discussing observations of the dark shadow upon Jupiter at the time of its occultation by the moon Aug. 7 last. Opinion seemed to be about equally divided as to the cause of the shadow, some regarding it as the effect of contrast between the bright edge of the moon and the fainter light of Jupiter's disk, others believing it to be due to the secondary spectrum fringe around the image of the moon. In this connection Mr. E. L. Trouvelot publishes in *L'Astronomie* for December, 1889, an observation made by himself Aug. 6, 1876, of an occultation of Saturn by the moon, which, as he says, "does not in any way confirm the phenomenon of the dark vaporous line extending along the edge of the moon, noticed by several observers during the last occultation of Jupiter."

Saturn is moving slowly through Leo, which constellation may be seen in the east in the evening. Saturn is the bright yellow star with steady light just below the familiar group of the Sickle, quite near to the first

magnitude star Regulus. In the June, 1889, number of the *Monthly Notices*, page 427, Mr. A. Marth called attention to an occultation of the satellite Japetus by the rings and globe of Saturn, beginning Nov. 1, 9.4*h*, and ending Nov. 2, 4.7*h* Greenwich mean time. In *Ciel et Terre*, Nov. 16, 1889, page 432, Dr. Terbe gives the following observations:

"Equatorial of 8 inches by Grubb; magnifying power, 132.

"Nov. 1, 3*h* 36*m* to 5*h* 03*m* A. M., image bad, agitated. *Japetus is perfectly visible*, I see also Titan, Rhea, and Dione, but I can not discover Tethys.

"Nov. 2 the state of the sky prevented observation before 5*h* 59*m* A. M.; from 5*h* 59*m* to 6*h* 24*m* sky splendid, image of irreproachable sharpness; I see constantly Titan, Rhea, *Dione* and *Tethys; I cannot discern the least trace of Japetus.*

"Nov. 3, 4*h* 24*m* to 4*h* 33*m* A. M.; image bad; clouds interrupt further observations. I see Titan, *Japetus*, Rhea, Tethys and Dione, these last four satellites are very near to Saturn, Japetus and Rhea below the west ansa of the rings; Tethys and Dione near the point of the east ansa."

Uranus will be in quadrature with the sun Jan. 16, and is in favorable position for observation in the morning. He may be found in the constellation Virgo about half way between Spica and the fourth magnitude star Kappa. There are several stars of about the same brightness in the vicinity, but with a telescope Uranus may be distinguished from the stars by his disk and dull green color.

Neptune may be observed during the whole night. He will be in conjunction with the moon Jan. 29, at noon. At 8 o'clock P. M., on that date, he will be about 4° or 8 diameters of the moon directly west of the latter.

Planetoids. We have been requested to give occasionally the places of the brighter planetoids. We shall be glad to comply with the request. During the coming month none of the bright planetoids will be in position for observation.

Sunspots have not been so numerous during the past three months as during the summer. On Dec. 20, however, two groups of spots and a large group of brilliant faculæ were observed at Northfield. At the last meeting of the Royal Astronomical Society (*Observatory* Vol. XII, p. 425), Father Perry, of Stonyhurst College Observatory, England, read a "Note on Solar Spots." "He said he thought he might as well call attention to the spots in the southern hemisphere which had been observed a long way from the equator. They all knew that as the minimum of sunspots was coming on a certain number of spots showed themselves in high latitudes. At present the spots were entirely confined to the southern hemisphere and at the end of last year one spot was seen in high southern latitudes, and they were at present increasing.

"On June 5th there was one in 29° south latitude. On 30 June there was a remarkable spot in 40° south latitude. They were seldom seen so far from the equator as that. That spot was observed in America, and he dared say it was observed at Greenwich, but he had only heard of it being observed at Stonyhurst and in America. On Aug. 2d there was a group of spots and another on Sept. 7th, but they were not in very high latitude; they were only 21°.3 and 22°, on Oct. 8th 28½°, and Oct. 10th 25°, so

that the number of spots was increasing in these high latitudes; and though he thought the minimum might not yet have arrived, because these spots generally showed themselves before the minimum, he thought they could not be far from it. The one at 40° was among the brightest on record. He did not think they could conclude that though those remarkable ones did follow the minimum there was such a variation in the period of eleven years that they could not be at all certain about the matter, but it seemed at present as if the spots were on the increase."

Mr. Maunder, of the Royal Observatory at Greenwich, confirmed Father Perry's observations of spots in high latitudes from the Greenwich daily photographs of the sun and said: "The general run of the recent phenomena of sunspots has given me the decided impression that the minimum is already past. A fine group came on the sun on June 16 last, and re-appeared in the two following rotations. Then a fine group appeared on Aug. 3 in southern latitude 22°, and this also has been seen in the two following rotations. Comparing the general aspect of the sun with that of 1879, the indications it presents now are similar to those after the former minimum was definitely passed. It is true that if the minimum be already passed we have not had so flat a trough for the solar wave as in 1878 and 1879, for we had then five months in which there were practically no spots at all. But if we take the mean daily spotted area of the sun for the first half of this year, stopping short at what seems to have been the commencement of the revival (the appearance of the group on June 16) we shall find it smaller than at the minimum in 1888. In 1878 the mean daily spotted area was 24 millionths of the sun's visible hemisphere; in 1888, 89 millionths; but for the half year ending June 15, 1889, it was only 18 millionths."

Professor Dr. Spoerer, of Potsdam, also calls attention to the same subject in the *Astronomische Nachrichten* No. 2936.

MERCURY.

1889.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Jan. 25	21 03.5	−13 56	7 36 A.M.	12 43.6 P.M.	5 51 P.M.
Feb. 4	20 18.9	−16 04	6 22 "	11 19.7 A.M.	4 18 "
14	20 13.9	−18 10	5 47 "	10 35.3 "	3 24 "

VENUS.

Jan. 25	20 09.7	−21 00	7 14 A.M.	11 49.8 A.M.	4 25 P.M.
Feb. 4	21 01.7	−18 08	7 14 "	12 02.2 P.M.	4 51 "
14	21 51.6	−14 24	7 07 "	12 12.6 "	5 18 "

MARS.

Jan. 25	14 45.3	−14 31	1 22 A.M.	6 26.3 A.M.	11 31 P.M.
Feb. 4	15 05.7	−16 02	1 09 "	6 07.2 "	11 05 A.M.
14	15 25.3	−17 22	12 55 "	5 47.5 "	10 40 A.M.

JUPITER.

Jan. 25	19 42.0	−21 37	6 50 A.M.	11 22.2 A.M.	3 55 P.M.
Feb. 4	19 51.7	−21 13	6 18 "	10 52.5 "	3 27 "
14	20 01.2	−20 48	5 46 "	10 22.7 "	2 59 "

SATURN.

Jan. 25	10 19.6	+12 12	7 05 P.M.	1 57.4 A.M.	8 50 A.M.
Feb. 4	10 16.9	+12 29	6 22 "	1 15.3 "	8 09 "
14	10 13.9	+12 47	5 38 "	12 33.0 "	7 28 "

URANUS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Jan. 25	13 40.0	− 9 45	11 52 P.M.	5 17.1 A.M.	10 42 A
Feb. 4	13 39.9	− 9 44	11 13 "	4 37.7 "	10 02
14	13 39.6	− 9 42	10 33 "	3 58.1 "	9 23 A

NEPTUNE.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	4 00.3	+18 54	12 17 P.M.	7 39.0 P.M.	3 01 A
Feb. 4	4 00.0	+18 54	11 37 "	6 59.4 "	2 22
14	4 00.0	+18 55	10 58 "	6 20.1 "	1 42

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
Jan. 25	20 32.7	−18 50	7 26 A.M.	12 12.7 P.M.	4 59 P
Feb. 4	21 13.5	−16 04	7 16 "	12 14.2 "	5 12
14	21 53.2	−12 51	7 02 "	12 14.4 "	5 27

Occultations Visible at Washington.

			IMMERSION.		EMERSION.		
Date.	Star's Name.	Magnitude.	Wash. Mean T. h m	Angle f'm N. P't. °	Wash. Mean T. h m	Angle f'm N. P't. °	Dt h
Jan. 24	B. A. C. 17	6	4 54	86	5 58	207	1
29	ε Tauri	3½	12 43	83	13 46	262	1
31	3 Geminorum	6½	12 23	53	13 22	312	1
31	6 Geminorum	6½	13 49	111	14 52	267	1
Feb. 2	84 Geminorum	6½	12 29	182	12 47	205	0
9	80 Virginis	6	15 23	114	16 45	317	1
12	ν^3 Scorpii	4½	16 12	143	17 19	270	1

Elongations and Conjunctions of Saturn's Satellites.

[Central time; E = east elongation; W = west elongation; I = inferior conjunction (north of planet); S = superior conjunction (south of planet.)

JAPETUS.

Jan. 22, S. Feb. 10, E.

TITAN.

Jan. 19	5.0 P.M.	I.	Jan. 31	3.2 P.M.	E.	Feb. 12	1.0 P.M.
23	4.4 P.M.	W.	Feb. 4	2.5 P.M.	I.		
27	3.8 P.M.	S.	8	1.7 P.M.	W.		

RHEA.

Jan. 17	12.3 P.M.	E.	Jan. 31	1.2 A.M.	E.	Feb. 13	2.1 P.M.
22	12.7 A.M.	E.	Feb. 4	1.4 P.M.	E.		
26	1.0 P.M.	E.	9	1.9 A.M.	E.		

DIONE.

Jan. 18	1.8 A.M.	E.	Jan. 29	12.4 A.M.	E.	Feb. 8	10.8 P.M.
20	7.4 P.M.	E.	31	5.9 P.M.	E.	11	4.4 P.M.
23	1.1 P.M.	E.	Feb. 3	11.6 A.M.	E.	14	10.1 A.M.
26	6.7 A.M.	E.	6	5.1 A.M.	E.		

TETHYS.

Jan. 17	4.6 P.M.	E.	Jan. 29	12.3 A.M.	E.	Feb. 9	9.9 A.M.
19	1.8 P.M.	E.	30	9.5 P.M.	E.	11	5.2 A.M.
21	11.1 A.M.	E.	Feb. 1	6.8 P.M.	E.	13	2.5 A.M.
23	8.5 A.M.	E.	3	4.0 P.M.	E.	14	11.8 P.M.
25	5.7 A.M.	E.	5	1.3 P.M.	E.		
27	3.0 A.M.	E.	7	10.6 A.M.	E.		

Phases of the Moon.

			Central Time. d	h	m	
New Moon	1890	Jan.	20	5	49	P. M.
First Quarter	"	"	27	2	16	P. M.
Full Moon	"	Feb.	4	7	14	P. M.
Last Quarter	"	"	12	12	51	P. M.
Perigee	"	Jan.	20	9	00	A. M.
Apogee	"	Feb.	2	8	00	A. M.

Periodic Comets to Return in 1890. Mr. W. T. Lynn in *Knowledge*, Dec. 2, 1889, p. 33, and Mr. W. E. Plummer in *The Observatory*, December, 1889, p. 432, give brief notices of the periodic comets whose return to perihelion is to be expected in 1890. There are four, possibly five of them, all telescopic and of short period, belonging to the Jupiter family of comets. Of these, two, Brorsen's and D'Arrest's, have been observed at several apparitions, but both escaped detection at the last return. The other three have been seen only at one apparition, so that their periods are somewhat doubtful.

Barnard's Comet 1884 II was discovered July 16, 1884, by E. E. Barnard, at Nashville, Tenn. The period assigned by Dr. Berberich is 5.36 years, so that this comet should be now very near perihelion. The elements of its orbit bear a close resemblance to those of the lost De Vico comet, 1844 I, and also to those of Finlay's comet 1886 VII. They cannot be identical, but probably belong to a system of faint comets which escape observation except when their perihelia are favorably situated with reference to the earth.

Brorsen's Comet was discovered at Kiel, Feb.26, 1846.• Its period is very nearly five and one-half years, so that its apparitions occur alternately in the spring and autumn. It was seen in 1857, 1868, 1873, and 1879, but escaped observation in 1884. It is due at perihelion this year about February 25, its course passing through the constellations Pisces, Andromeda, and Cassiopeia. It should not escape detection this time. In another place Mr. G. A. Hill gives a sweeping ephemeris which will aid observers in their search for the faint visitor.

Mr. Plummer says: "The orbit is a very interesting one, for it approaches very closely to that of Jupiter and at intervals of ninety-five years the comet encounters the planet, and a very decided change in the orbit ensues. This close approach last occurred in 1842 May, when the comet's motion, which had been previously hyperbolic was changed into the elliptical form in which the comet now moves. In 1937 this proximity will again take place, when the orbit will probably resume its hyperbolic curve, and be lost to the solar system."

Coggia's Comet, discovered Nov. 10, 1873, was thought, from the investigation of Professor Weiss, to be identical with one detected Feb. 23, 1818, by Pons, but, although the derived period is about five and one-half years, it has not been seen since 1873. If this period is correct the comet is due early in 1890. We have no ephemeris at hand.

Denning's Comet 1881 V, discovered at Bristol Oct 4, 1881, has been thought to be identical with that discovered by Blanpain Nov 28, 1819, for which Encke derived a period of 4 8 years. The most reliable orbit of Denning's comet, however, gives a period of 8 6874 years This period, computed by Dr. Boy Matthiesen (A. N. 121, p. 359), has a probable error of only four days, so that the comet should come to perihelion in May, 1890, but with a theoretical brightness of only one-third that which it had when discovered in 1881. Also the comet in 1887 approached very near to Jupiter, so that its orbit may have suffered considerable perturbations, which must be calculated approximately before a sweeping ephemeris can be computed.

D'Arrest's Comet was discovered at Leipzig June 27, 1851, it has a period of six and a half years and was seen in 1857, 1870 and 1877 but was not seen at its last return in the winter of 1883. According to Winnecke this is the faintest of the periodic comets, but its course this year will be similar to that which it followed in 1883, when it was a fairly conspicuous object in the telescope. This comet is due at perihelion about the third week in September. An accurate ephemeris will doubtless be soon published. Such ephemerides have hitherto been issued by M. Leveau, of Paris.

Comets of 1887–8.

Comet 1886	VIII	1887 *c*	Barnard, Jan. 23.
Comet 1887	I	1887 *a*	Thome, Jan. 18.
Comet 1887	II	1887 *b*	Brooks, Jan. 23.
Comet 1887	III	1887 *d*	Barnard, Feb. 16.
Comet 1887	IV	1887 *e*	Barnard, May 12.
Comet 1887	V	1887 *f*	Brooks, Aug. 24...Olbers's.
Comet 1888	I	1888 *a*	Sawerthal, Feb, 18.
Comet 1888	II	1888 *b*	Encke's Comet.
Comet 1888	III	1888 *c*	Brooks, Aug. 7.
Comet 1888	IV	1888 *d*	Faye's Comet.
Comet 1888	V	1888 *f*	Barnard, Oct 30.
Comet 1889	I	1888 *e*	Barnard, Sept. 2.

O. C. WENDELL.

Harvard College Observatory, Dec. 6.

The Return of Brorsen's Comet. This comet is now almost due. In the *Astronomische Nachrichten*, No. 2220. Dr. Schulze, of Dobeln has made an extended investigation of the orbit of this comet, and from his elements for 1879, brought up to 1890, I have computed the following sweeping ephemeris. The period of the comet is becoming less, as will be seen by the following intervals as deduced from the five observed returns.

1846,	2034.1 days.
1857,	2022.7 days.
1868,	2002 4 days.
1873,	1999 4 days.
1879,	1994.9 days.

As the comet was missed in 1884 I have used 3929 days as the date of the next perihelion passage or twice that as shown by Dr. Schulze's elements for 1879, namely 1994.9 days. I then decreased the period by 12 days and computed another ephemeris. The two will be found below.

These two values give as the dates of perihelion passage Feb. 17 and March 1, 1890, respectively. Dr. Lamp, of Kiel, has an ephemeris for this comet in a late number of the *Nachrichten*. He has made the date of the next perihelion passage on Feb. 24, 1890, which is intermediate to those selected by me.

GEO. A. HILL.

Naval Observatory, Washington, D. C., Dec. 19, 1889.

Sweeping Ephemeris for Brorsen's Comet.

Perihelion Passage March 1, 1890.

DATE.	α h	m	s	δ °	′	Δ
Dec. 31	22	55	30	− 32	45.4	0.17165
Jan. 1		56	39	32	23.5	
2		57	48	32	1.5	
3		58	57	31	39.5	
4	23	0	7	31	17.5	0.16650
5		2	44	30	51.4	
6		5	21	30	25.3	
7		7	58	29	59.2	
8		10	35	29	33.0	0.15245
9		12	35	29	6.4	
10		14	36	28	39.8	
11		16	37	28	13.2	
12		18	38	27	46.6	0.14122
13		20	43	27	18.0	
14		22	49	26	49.4	
15		24	55	26	20.8	
16		27	1	25	52.1	0.12806
17		29	46	25	18.5	
18		32	32	24	44.9	
19		35	7	24	11.3	
20		37	43	23	37.7	0.11044
21		38	28	23	7.5	
22		39	13	22	37.2	
23		40	58	21	7.0	
24		42	43	21	36.7	0.09628
25		45	28	20	59.4	
26		47	13	20	22.1	
27		50	28	19	44.8	
28		53	44	19	7.5	0.08153
29		56	2	18	28.2	
30	23	58	20	17	48.9	
31	0	0	38	17	9.6	
Feb. 1		2	57	16	30.3	0.06069
2		5	15	15	45.3	
3		7	34	15	0.3	
4		9	53	14	15.3	
5		12	12	13	30.2	0.04087
6		14	28	12	41.3	
7		16	44	11	52.3	
8		19	0	11	3.3	
9		21	17	10	14.3	0.01713
10		23	28	9	20.1	
11		25	39	8	25.9	
12		27	55	7	31.7	
13		30	2	6	37.5	
14		32	7	5	32.6	9.99198
15		34	12	4	27.7	
16		36	17	3	22.8	
17	0	38	22	− 2	17.9	9.95791

Perihelion Passage Feb. 17, 1890.

DATE.	α h	m	s	δ °	′	Δ
Dec. 31	23	0	55	− 32	47.8	0.09176
Jan. 1		2	18	32	18.7	
2		3	22	31	50.1	
3		4	36	31	21.5	
4		5	50	30	52.9	0.07928
5		8	11	30	48.3	
6		10	33	29	49.6	
7		12	55	29	18.0	
8		15	17	28	46.3	0.05917
9		16	0	28	16.5	
10		16	44	27	46.7	
11		17	28	27	16.9	
12		18	12	26	47.1	0.04483
13		20	41	26	5.6	
14		23	10	25	34.8	
15		25	39	24	53.3	
16		28	8	24	21.0	0.02843
17		30	0	23	41.8	
18		31	52	23	2.6	
19		33	44	22	23.4	
20		35	37	21	44.2	0.00709
21		37	25	21	0.8	
22		39	13	20	17.4	
23		41	1	19	34.0	
24		42	49	18	50.6	9.98321
25		44	29	18	2.0	
26		46	10	17	13.3	
27		47	51	16	24.7	
28		49	32	15	35.9	9.95661
29		51	0	14	41.6	
30		52	28	13	47.2	
31		53	56	12	52.9	
Feb. 1		55	24	11	58.5	9.92693
2		56	8	10	52.9	
3		57	32	9	47.3	
4		58	36	8	41.7	
5	23	59	41	− 7	36.0	9.88888

Comet d 1889 (Brooks, July 6), was observed on six nights from Nov. 14 to Nov. 26, by Professor Young and his assistant, Mr. Miller, with the 23-inch equatorial, at Princeton. "On Nov. 14 both observers saw the companion comet, about 5′ from the principal comet, at a position angle of between 50° and 60°. It was still better seen on the 15th by Mr. Miller but not quite well enough to admit of observation on the bars. The main comet was decidedly elongated by a short brush 1½′ in length directed nearly toward the companion." The best elements of this comet are probably those given below, computed by Dr. O. Knopf, (A. N. No. 2936)

whence the period is 7.071 years. In *Astronomical Journal*, No. 204, Mr. S C. Chandler has published very similar elements with a period of 7 039 years. He calls attention to the very close approach of the comet to Jupiter in 1886 when for three months the distance between them did not exceed 0.100 of the earth's distance from the sun It is probable that the character of the orbit was radically changed in that time.

ELEMENTS.

$$T = 1889 \text{ Sept. } 29.7436 \text{ Berlin M. T.}$$

$$\left.\begin{aligned} \omega &= 343°18'56.5'' \\ \Omega &= \;\;17\ 58\ 29.6 \\ i &= \;\;\;\;6\ \ 8\ 59.6 \end{aligned}\right\} \text{Mean Equinox 1889.0}$$

$$\varphi = \;28\ \ 4\ 13.3$$

$$\mu = 501''.8156$$

$$U = 7.071 \text{ years.}$$

EPHEMERIS.

1890	α h m s	δ ° ′	log r	log Δ	L.	1889.	α h m s	δ ° ′	log r	log Δ	L.
Jan 4	0 43 54	+ 7 52.6	0.3243	0.2752	0.6	Jan 27	1 23 18	+ 12 10.8			
5	47 26	8 3.8				28	25 1	12 21.9	0.3406	0.3472	0.4
6	48 58	8 15.1				29	26 44	12 33.0			
7	50 31	8 26.3				30	28 28	12 44.0			
8	52 5	8 37.6	0.3269	0.2878	0.5	31	30 12	12 55.0			
9	53 39	8 48.8				Feb 1	31 57	13 6.0	0.3435	0.3583	0.4
10	55 14	9 0.1				2	33 42	13 17.0			
11	56 49	9 11.4				3	35 27	13 27.9			
12	0 58 25	9 22.7	0.3295	0.3002	0.5	4	37 12	13 38.8			
13	1 0 1	9 34.0				5	38 58	13 49.6	0.3464	0.3691	0.3
14	1 38	9 45.3				6	40 44	14 0.4			
15	3 15	9 56.6				7	42 31	14 11.2			
16	4 53	10 7.8	0.3322	0.3123	0.5	8	44 18	14 21.9			
17	6 31	10 19.1				9	46 5	14 32.6	0.3493	0.3797	0.3
18	8 10	10 30.3				10	47 52	14 43.3			
19	9 49	10 41.5				11	49 40	14 53.9			
20	11 29	10 52.7	0.3350	0.3242	0.4	12	51 28	15 4.5			
21	13 9	11 3.9				13	53 16	15 15.0	0.3523	0.3900	0.3
22	14 50	11 15.1				14	55 4	15 25.5			
23	16 31	11 26.3				15	56 53	15 36.0			
24	1 18 12	11 37.4	0.3378	0.3358	0.4	16	1 58 42	15 46.4			
25	1 19 54	11 48.6				17	2 0 32	+ 15 56.8	0.3553	0.4000	0.3
26	21 36	+ 11 59.7									

Comet f 1889 (Swift, Nov. 17) was observed at Lick Observatory Nov 20, 21, 22, 25 and 26.

New Comet g 1889 (Borrelly, Dec. 12). A telegram, Dec. 15, announces the discovery of a faint comet by Borrelly at Marseilles. Position, Dec 12.311 Gr. M. T., R A 18*h* 07*m* 00*s*; Decl. + 48° 53′, daily motion, + 1*m* 12*s*; south 1°. *Astronomical Journal*, No. 207, has an observation by Barnard Dec. 15.6425 Gr M. T., R. A. 18*h* 0*m* 0.115*s*; Decl + 45° 30′ 10″.

The Hartford Fire-Ball In the Hartford *Courant* of Dec. 12, 1889, an interesting, though somewhat indefinite, account is given of the fall of a fire-ball, the fragments of which seem to indicate that its origin was meteoric. The fall was observed on Tuesday evening, Dec. 10, at 8*h* 15*m*, in the midst of Seyms street, opposite the residence of Mr. Charles B. Andrus. So far as now known it was only seen by a lad twelve years of age, who claims that he saw "a big ball of fire fall in the middle of the street." By those who looked into the matter it is thought that the object came from the northwest quarter of the heavens, at an angle of elevation of thirty or forty degrees. At the place of its fall fragments were found, and the

ground for a foot and a half square was colored a greyish white shade by the fine ashes which apparently were thrust into the soil that formed a thin covering of a road made of crushed stone. There were no large fragments, and the appearance of those most carefully examined led to the belief that the object was a meteorite.

Brilliant Meteor. December 17, at *4h 45m* P. M., I witnessed a most remarkable meteoric flight. Pardon the full details as I wish the occurrence to be correctly stated for the purpose of comparison with other possible observations of the same object. I went to my Observatory to make some repairs and as I reached the front of it, and facing east the meteor flashed into view. As may be judged by the time it was still strong daylight, but so bright was the meteor that it attracted my attention immediately. It was fully as bright as Venus would appear in a dark sky, and at the most favorable position in her orbit for greatest brightness. What struck me most was the decided green color of the meteoric light. The color to me was intense. Following the meteor was four or five attendant but lesser objects, which seemed to be of an orange color. I give below a general view of the transit, and wish to call attention to the rays emanating eastward from the prim-ary, and which seemed remarkable on account of the strong sunlight present.

The position of these rays, as above, is about as I saw them, and may indicate more than ordinary atmospheric appearances. Unfortunately the sky was not wholly free from clouds and haze, and the termination of the passage may be in error. I extract from the notes the following positions to which I may add that they were obtained by the circles of the telescope after careful reference to the position of objects relative to the witnessed path:

Apparition in δ $= +21°$ nearly.
Extinction in δ $= -\ 9°$ "
Altitude by hour circle $=\ 15°$ "

WILLIAM EDWARD WOOD.

Washington, D. C.

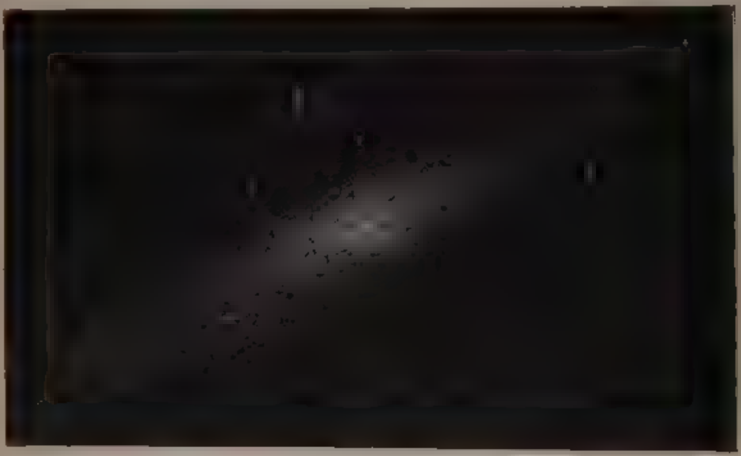
United States Scientific Expedition to West Africa. We have received Bulletins Nos. 3 and 5 of the United States Scientific Expedition to West Africa under the direction of Professor D. P. Todd, of Amherst College. These respectively relate to "Fish of the Congo Basin" and "Bibliography of Ki-mbundu."

On Dec. 23 news came *via* London from St. Paul de Loando to the effect that numerous photographs of the eclipse were obtained by the American Expedition during the period of totality. It is reported that clouds gave some trouble, but the apparatus in use worked perfectly. The photographs made on the ship Pensacola which stood far out at sea are likely to be particularly useful. It is also reported that the English observers at St. Paul de Loando obtained no good observations on account of bad weather. We hope for better reports later.

NEWS AND NOTES.

We have found it difficult during the last two months to secure, within easy reach the quality of engraving desired for the illustration of some articles already in hand. After three unsuccessful trials by artists in St. Paul and Chicago, supposed by us to be among the best, we have deferred one biographical sketch until next month. We are still trying with hope of success

The beautiful frontispiece picture of the great nebula of Andromeda is a copy from the last issue of *Himmel und Erde.* It is presented at this time to accompany the article entitled "News from the Nebulæ," by Professor Young and elsewhere given in this number. If the reader compares the cut given below, with the fine photograph by Roberts of England, of which our frontispiece is a close process copy he will find it difficult to believe that the two pictures represent the same object This one gives the the appearance



of the nebula as seen in Herschel's telescope and as pictured in some excellent text-books on astronomy now in use. The later drawing by Trouvelot shows the two nearly parallel canals, so-called, observed by Mr Bond at Cambridge, some years ago by the aid of the 15-inch refractor. We now know the shape and extent of these canals and the general features of this grand nebula, which is one of the late noble triumphs of celestial photography But, surely, this is only the beginning of wonders, as we believe from that astonishing article by professor W. H. Pickering, the leader of this number. We supposed we knew something about old Orion, but his "bands" are apparently infinitely more than those that Job saw

Wm M. Pierson, vice-president of the Astronomical Society of the Pacific, has recently set up an 8½-inch reflecting telescope in his private Observatory in San Francisco The instrument was made by J A. Brashear, of Alleghany City, Pa., is equatorially mounted with driving clock and circles, and has proved very satisfactory to its owner.

Astronomical Society of the Pacific. By the kindness of Mr. Charles Burckhalter, secretary of the Astronomical Society of the Pacific, and of members of the staff of Lick Observatory, we are able to give the results of much valuable recent work for astronomy from the western coast. It is a great pleasure to us to notice the general interest in our science that has so quickly sprung up on the other side of the Rockies. But it is more wonderful still to know the kind of astronomical work this young society is doing. It is certainly work that matches well the best of its kind we know of. The officers have also done nobly, as we think, to enlist a general public interest in what they are doing, and the consequence is quick and generous aid, in the way of donations, as illustrated by Mr. Montgomery's handsome gift of $2,500. The society is congratulated on its unusual success in so many ways.

Annual Report of Harvard College Observatory. The forty-fourth annual report of the Director of the Astronomical Observatory, of Harvard College, was presented to the Visiting Committee Dec. 14, 1889. This report speaks of the death of Mr. J. I. Bowditch, an old and active friend of the Observatory, the Bruce gift of $50,000, the continued aid of Mrs. Draper and that of the Boyden Fund for the Peru expedition, which enables the Observatory to extend its important investigations to include the southern stars. A second expedition to Southern California furnishes the Observatory a mountain station, under climatic conditions superior to those of the eastern portion of the United States.

The east equatorial has been mainly used by Mr. Wendell, and it has six new eye-pieces and two square bar micrometers made of tinfoil mounted on glass by Professor Rogers. This instrument has been busy, evidently, from the range of work done by it. The Meridian Circle has been used in observing the southern zone, comprising the declination from $-9° 50'$ to $-14° 10'$, by Professor Searle and Mr. Dunne. The total number of observations is 8565: 287 relating to circumpolar stars, 1,024 to fundamental stars, 6889 to zone stars, and 365 to stars incidentally observed. Reductions of the Meridian Circle observations are being forwarded as rapldiy as the limited force of computers can do the work. The twelve-inch horizontal telescope has been used by Mr. G. E. Hale in an investigation of the solar spectrum.

In the latter part of this report, fuller mention is found of the uses made of the Boyden fund, the Bruce Photographic Telescope, now in process of construction, which is to be 24-inches clear aperture, with focal length of eleven feet, and its contemplated work; the library, the time service, telegraphic announcements and publications for the year, all of which indicate an excellent showing for the work of this Observatory.

Professor A. E. Haynes, Department of Mathematics and Astronomy, Hillsdale College, Michigan, some time ago called our attention to an observation of the Crater Ptolemais, made Dec. 10, 1888, at 8 o'clock P. M., Standard Central time. He saw a part of the bottom of the Crater Ptolemais lighted up by reflection from the lighted edge. He has not before nor since observed the same phenomenon.

Notes from the Advance Sheets of the Publications of the Astronomical Society of the Pacific.

Great Telescope for Los Angeles. Authentic information regarding the proposed forty-inch refractor for Wilson's Peak is difficult to obtain A newspaper report of an interview with Mr. A. G. Clark on September 28, recites that one of the discs (now on exhibition at Paris) probably arrived in Boston in October. The other disc is not yet cast, and M. Mantois is, apparently, not willing to undertake the work without a contract, which is not yet executed. The trustees of the Fund have, so it is said, authorized Mr. Clark to pay $10,000 for two satisfactory forty-inch discs, which is not an unreasonable price by any means. Mr Clark offered to make the objective and the mounting for $100,000, during his visit to California in the winter of 1888-9. So far as is now known, the fund available for the telescope does not yet exceed $150,000. Probably $300,000 to $400,000 would build and equip the Observatory. E. S. H.

Force of Gravity at Mt. Hamilton and San Francisco. Mr. E. D. Preston of the U. S. Coast and Geodetic Survey has published his report on gravity determinations in the Pacific Ocean (Bulletin No. 11, U. S. C. and G. S., 1889). The force of gravity at Washington being 1.000000, that at San Francisco (Professor Davidson's Observatory) is 0.999854 and at the Lick Observatory it is 0.999544. Determinations of *g* at four stations in the Hawaiian Islands and for a station at Caroline Island are also given.

E. H. S.

Rainfall on Mount Hamilton. Meteorological observations have been kept at Mount Hamilton since 1880. The following table of rainfall on the summit is the best available summary. This rainfall is considerably more than that in the Santa Clara Valley near San Jose (about 13.4 inches) and it is probably considerably less than the fall in some of the canyons and valleys immediately surrounding the mountain. The great variations in the annual amount of rainfall are interesting from a meteorological point of view, and decidedly inconvenient from a practical one, especially as our reservoir capacity is not quite adequate. E. S. H.

Rainfall at Mount Hamilton in the years 1880–89.

Month	1880-81	1881-82	1882-83	1883-84	1884-85	1885-86	1886-87	1887-88	1888-89
	in	in	in.	in	in	in	in	in	in
July	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
August	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.02
September	0.00	0.10	0.00	0.65	0.65	0.15	0.00	0.33	0.43
October	0.00	0.33	6.16	2.15	3.71	0.05	0.60	0.09	0.09
November*	0.50	0.91	3.45	1.48	0.01	—	2.82	0.90	3.27
December	9.68	9.72	1.93	2.05	33.84	—	2.34	11.25	4.23
January	3.51	3.55	3.10	5.60	1.99	—	2.83	10.04	1.04
February	5.99	2.90	3.75	12.76	0.57	1.80	7.80	1.38	1.42
March	1.13	5.40	8.66	16.35	1.15	5.77	1.39	3.40	6.17
April	0.98	4.70	2.66	11.96	2.08	[illegible]	5.75	0.68	1.92
May	0.09	0.48	7.55	1.24	0.16	0.70	0.25	1.25	3.21
June	0.33	1.06	0.00	3.85	0.36	0.00	0.30	0.67	0.00
Sums	22.21	29.15	37.26	58.09	44.67	0.00	24.08	30.03	21.80

* November, 1880—One shower, amount assumed to be 0.50 in.

Mean annual rainfall (8 years), July to July = 33.41 in.

Stability of the Great Equatorial. Observations for the position of the great telescope have been made by Messrs. Schaeberle and Keeler, as below:

1888, July 27,	azimuth	= + 36″;	level	= 8″	too low.
1889, May 18,	"	= ——	"	= 36″	" "
Sept. 16,	"	= + 83″	"	= 58″	" "

There appears to be a slight progressive change in level and probably in azimnth. I.

Lick Observatory Photographs of the Moon. Knowledge for Oct. 1, 1889, contains an article by the editor (Mr. Raynard), on the Moon as seen in the Lick Telescope. Excellent reproductions of five silver prints made by the Direct Photo-Engraving Company of London, accompany the article. Mr. Raynard's remarks upon the temperature of the moon and upon the possibility of the existence of snow fields on its surface, are well worth close attention. E. H. S.

Mountain Observatories. Telescopes . . . . "cannot be formed so as to take away that confusion of rays which arises from the tremors of the atmosphere. The only remedy is a most serene and quiet air, such as may perhaps be found on the tops of the highest mountains above the grosser clouds."—Sir Isaac Newton, in his *Opticks*, A. D. 1730.

Latitude by the Zenith Telescope. Continental astronomers have lately employed the zenith telescope in determining latitudes at many stations. With other instruments arranged for this method the results have been so favorable, that Wauschaff, of Berlin, has constructed a zenith telescope whose accuracy is remarkable; the probable error of observation upon a pair of stars for one night being but ± 0.″15, (fifteen hundredths of a second) at the station Schucekoppe of the Geodetic Institute of Berlin. The observer was Professor Albrecht; the instrument has an objective of Jena glass of 2½ inches in aperture, and two delicate levels for mutual control. T. H. S.

Repairs at Ann Arbor. The dome of the Observatory at Ann Arbor was put up some thirty-five years ago and has received little attention since. It moves on five cannon balls, and, in the course of years, the rotation of the dome has become more and more difficult, until it is now practically immovable. At their last meeting, the Regents of the University authorized its repair and the matter has been placed in the hands of Warner and Swazey, of Cleveland, who will put in their superior running apparatus. The work will probably not be completed before the first of next April. The same manufacturers will also put their shutter on the dome.

Annual Companion to the Observatory, 1890. This very useful publication for the year 1890 is promptly at hand. Although somewhat re-arranged and abridged, it still contains everything of importance to be expected in such a publication. The readers of The Messenger who use information of this kind can not do better than to secure a copy of the Companion to the Observatory for the year 1890.

The Fauth Meridian Circle of Cincinnati Observatory. I am glad to respond to your request for some notes concerning the work of this Observatory, and especially with respect to the performance of the New Meridian Circle. The most satisfactory test of the excellence of an instrument is undoubtedly to be obtained from the discussion of an extended series of observations made with it. For such a test of our Meridian Circle we have now abundant material, for since the instrument was set up in August, 1888, over 3,000 observations have been taken. The greater part of these are of proper-motion stars, the re-determination of their movements, and the compilation of a catalogue of these interesting objects being the chief work upon which we are now engaged. The portion of this catalogue covering the first six hours of right ascension is already nearly completed. Before the remainder can be finished it will be necessary to await the appearance of the rest of the new Paris Catalogue, so that advantage may be taken of the many new cases of proper motion which the comparison of modern observation with Lalande's positions is sure to bring to light.

Besides the class of work referred to, we have taken part in the observations of the minor planets, Victoria and Sappho, and their comparison stars according to the programs published by Dr. Gill. Of the 42 stars in the first series, 186 observations were made, and 8 of the planet itself. Of the 43 stars in the second series, 244 observations were obtained, and 16 of the planet. Each star was observed in both positions of the circle, but a comparison of the results, west and east, shows no systematic differences either in right ascension or declination. The average probable error of a single observation as computed from the Victoria stars gave ± 0.056s in right ascension, and ± 0.58″ in declination; but several nights were employed when the definition was far from good. During the fall months when the second series was observed the average definition was somewhat better, and the resulting probable errors show a decided improvement, being ± 0.050s and ± 0.44″ respectively. I may mention that only one observation was rejected, and that was marked poor at the time. These values will compare favorably with those obtained by instruments of similar size, but the principal danger to be feared is not the accidental errors of observation so much as constant errors. If a star is always observed upon the same divisions of the circle, no matter how well the individual results agree, we can never be sure that we have the true declination. This danger can be avoided by shifting the circle at the end of each year and re-observing the same stars upon different divisions. This plan has been adopted here, but as yet no evidences of any constant error have been detected.

Another good test of the accuracy of the graduation is obtained from the agreement of the equator point as given by the observation of fundamental stars differing widely in declination. In our practice six such stars are usually observed on each night, one or two being circumpolar stars. The average probable error of the equator point from a single star comes about half a second. Into this, of course, enters the uncertainty of the star positions and of the refraction, as well as the errors of graduation. The stability of the instrument and the ease with which it is manipulated are very satisfactory. On the whole Messrs. Fauth and Saegmueller are to be congratulated on the excellence of their workmanship. J. G. PORTER,

Dec. 17, 1889. Director of Cincinnati Observatory.

A Wonderful Nebulous Ring. In about the year 1865 while comet-seeking with a 4½-inch telescope, I swept across an object which, from its size and peculiar appearance, I thought might be either a comet or, more likely, a glow from a cluster of bright stars closely adjoining it. Subsequently, finding no motion, I settled upon the latter theory, but, observing it several times during succeeding years, I came to notice that the supposed glow was all on one side of the cluster, and became convinced that it was a nebula. probably a well known one.

In 1880 I came into possession of Sir John Herschel's General Catalogue of Nebulæ, and made immediate search for my mysterious find, of which there was no record.

After my removal to Rochester I received a letter from Professor Barnard then of Nashville, Tenn., saying he had discovered a large nebula not in General Catalogue which he, at first, had mistaken for a comet.

On exceedingly favorable occasion as to purity of the atmosphere, and before the erection of the electric street lights, I examined it with the 16-inch instrument of this Observatory, when I saw it as I have never since been able to do, even under conditions apparently as favorable. An imperfect illustration of its then appearance will be found on page 57, Vol. III of THE SIDEREAL MESSENGER, and on page 21 of "History and Work of the Warner Observatory." Although I have not since seen it as an ellipse with condensations at each focus, yet I have observed what I, at that time, failed to notice; viz., three knots of considerable extent north preceding the nebula, seemingly connected with each other not only, but also with the parent nebula.

Thus the matter rested until Barnard informed me that, with the 12-inch glass of the Lick Observatory, he had discovered a nebulous ring entirely surrounding the cluster which I, myself, also saw at my visit to that observatory, and found that my nebula, as also the three knots, formed part of the ring.

Professor Barnard in *Astronomische Nachrichten*, No. 2918, has given an interesting account of his discovery, accompanied by a faithful illustration of not only the cluster, but also of its inclosing ring, which, the Milky Way excepted, is the largest visible to us, its outer diameter being not less than 40′. In comparison, the ring nebula in Lyra is a pigmy. Mr. Barnard, in his drawing, shows the segment of another ring apparently attached to the principal one on the *s. f.* side, and, judging from the visible portion, it, if continuous, must be nearly as large as the other. This I did not see.

The cluster is H. 2. VII = G. C. 1420, and the nebula is N. G. C. 2237, R.A. 6*h* 24*m* 48*s*, Decl. + 5°8′, in the constellation Monoceros. As it will soon be favorably situated for observation, I shall hope that the distinguished celestial photographer, Mr. Isaac Roberts, will be induced to photograph it, as a change both in brightness and form is suspected.

Warner Observatory, Rochester N. Y. LEWIS SWIFT.
Dec. 20th, 1889.

Large versus Small Telescopes—A Special Case. The following is an attempt to compar the 26-inch equatorial of the Leander McCormick Observatory with the 10-inch of the Haverford College Observatory, by means of the two series of double-star measures made at these observatories. Both

telescopes were made by the Clarks and are probably equal in optical perfection. The micrometer and driving clock of the McCormick instrument are excellent, while the Haverford ones are very indifferent. However the Haverford series of measures have the advantage, in that they were made after the McCormick series. If we assume that, on an average, the atmospheric conditions were the same, we may consider that the two series of measures were made under pretty much the same circumstances.

The observations considered were made by myself, the McCormick series in 1886, the Haverford series in 1888. The probable error of a single night's observation was computed, only those stars being used which were observed at both places. The results are shown in the following table, where *P* represents the probable error in position angle, and *D* represents the probable error in distance.

Mean of Distances.	P	D	Mean of Distances.	P	D	Series.	Magnifying Power.
0″.7	1°.2	0″.07	1″.8	0°.5	0.12	M	850
0 .7	2 .4	0 .06	1 .8	1 .0	0.08	H	375

It was the custom to observe on a given night always the closest and most difficult stars that the definition would allow. The number of difficult stars in a hundred measures will, therefore, furnish another means of comparison. On an average there were 20 measures in a hundred in the McCormick series, where the distance was between 1″.0 and 0″.5, and there were 5.7 measures where the distance was less than 0″.5. In the Haverford series the numbers were respectively 21 and 4.6.

Again, in all the observations with the McCormick instrument the stars were invariably seen as easily separated, while in the Haverford telescope the most difficult ones could not be separated but merely elongated.

F. P. LEAVENWORTH.

Photographing the Corona without an Eclipse. From a brief account, in the December Observatory, of experiments by Dr. Huggins, of England, it seems that astronomers may yet hope to photograph the corona without the aid of an eclipse. This most delicate work needs the best conditions of atmosphere possible, which the climate of England very rarely furnishes. Still Dr. Huggins, after waiting for years for a favorable opportunity, has realized some promise of success. The clear atmosphere of Athens is to be tried in the hope of a speedy solution of this most interesting problem of solar physics. At Captain Darwin's suggestion, Rev. A. J. Perry and Mr. Taylor were to try, during the eclipse of Dec 21, to learn how long after totality the moon could be seen against the corona The Lick party obtained a good photograph in this way Jan. 1, 1889.

Chamberlin Observatory By kindness of Mr. George N. Saegmuller, successors to Messrs. Fauth and Company, Washington, D. C., we have had the privilege of examining the drawings and specifications for the mounting of the new 20-inch refractor for the Chamberlin Observatory at Denver, Colorado. This work seems to combine all the latest and best improvements known to modern astronomy, and the appearance now is that Professor Howe will have the satisfaction of using one of the finest telescopes of which this country or any other can boast. Attention is called to Mr. Saegmuller's new advertisement.

Errata. On page 405, Vol. VIII, line 10 from the top, 1887 should be 1888.

MARIA MITCHELL.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. [illegible]

DIRECT[illegible] CARLET[illegible] COLLEGE [illegible] N[illegible]

[illegible] 9, No. 2. [illegible] WHOLE No. [illegible]

MARIA MITCHELL.

[illegible]

[illegible]

Maria Mitchell was born [illegible] Nantucket, Aug. [illegible] 1818. Her father and [illegible] Quakers, and her mother was descended [illegible] earliest settlers of the island. Her father [illegible] to scientific study, and throughout his [illegible] and afterwards as bank cashier, [illegible] leisure time [illegible] astronomical pursuits. He was [illegible] employed [illegible] the United States Coast Survey [illegible] pertaining to the survey of the island. [illegible] observations his daughter began to assist him at the [illegible] of [illegible]. Her education was the best Nantucket [illegible] thoroughly substantial but simple [illegible] gave her only the rudiments of the science, [illegible] mathematics which her later studies required. When eighteen years old [illegible] librarian of the Athenaeum [illegible] library well supplied with scientific books, and [illegible] the [illegible] character of the Quaker town [illegible] reading [illegible] this library, Miss Mitchell, [illegible] reading, laid the foundations of her mathematical knowledge. Throughout these years she continued her father's assistant, and gradually passed to independent observations. She [illegible] comets on the roof of the Pacific bank, still [illegible] main street of Nantucket. She found several before their discovery was known to her, and in the mean time was training herself by study for the investigation of the positions she obtained. She computed several orbits from her own observations. But not until 1847 did she sweep her glass over that particular comet which brought her to the notice of the public.

* [illegible] of the Observatory, Vassar College, Poughkeepsie, N. Y.

THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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MARIA MITCHELL.

MARY W. WHITNEY.*

For THE MESSENGER.

Maria Mitchell was born on the island of Nantucket Aug. 1, 1818. Her father and mother were both Quakers, and her mother was descended from the earliest settlers of the island. Her father had a natural taste for scientific study, and throughout his active life, first as teacher and afterwards as bank cashier, he devoted his leisure time to astronomical pursuits. He was for many years employed by the United States Coast Survey in observations pertaining to the survey of the island. In these observations his daughter began to assist him at the early age of eleven. Her education was the best Nantucket could afford, of a thoroughly substantial but simple character. It gave her only the rudiments of the science, and the mathematics which her later studies required. When eighteen years old she became librarian of the Athenæum library, an excellent library well supplied with scientific books, and attesting the intellectual character of the Quaker town. In the reading room of this library Miss Mitchell, by her private reading, laid the foundations of her mathematical knowledge. Throughout these years she continued her father's assistant, and gradually passed to independent observations. She swept for comets on the roof of the Pacific bank, still heading the main street of Nantucket. She found several before their discovery was known to her, and in the mean time was training herself by her study for the investigation of the positions she obtained. She computed several orbits from her own observations. But not until 1847 did she sweep her glass over that particular comet which brought her to the notice of the public.

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Of this she was original discoverer. A more extended knowledge of this discovery was doubtless brought about through the conferring of the Danish medal. Some years previous to this the King of Denmark had offered medals for the discovery of comets, his object being to incite his own subjects to a more zealous pursuit of astronomical investigation. But the medal in this case was sent across the Atlantic to the young woman in Nantucket.

The public interest aroused by this discovery brought to Miss Mitchell wider opportunities. A Clark telescope of five inches aperture, well equipped and mounted, was presented to her She was appointed computer for the American Ephemeris and Nautical Almanac, and was on many occasions employed by the Coast Survey for astronomical work. She traveled abroad and met the leading astronomers of England and the continent. Sir John Herschel and Sir George Airy became her friends and maintained correspondence with her. She traveled in Europe a second time several years later, and during this tour made a visit to the famous Russian Observatory at Pulkowa. Her interest in cometary work, both practical and theoretical, continued, and after she came into possession of a well-mounted instrument she took up also the study of double-stars.

In 1865 Miss Mitchell was appointed professor of Astronomy at Vassar College. This college for young women, the pioneer college in the East, was opened to the public in the fall of that year. Miss Mitchell had not sought this appointment; she did not regard herself as especially well fitted to teach nor as possessing those gifts which fit one for professional work Nevertheless this unsought position offered many inducements, and Miss Mitchell had naturally become much interested in the extension of the educational opportunities of young women. Therefore she decided to enter the new field. As her principal duties hereafter were those pertaining to the class room, her instrumental work was necessarily curtailed, but her interest remained unabated and she devoted all the time at her command to the telescopes. Her first investigations were, of course, those pertaining to the latitude and longitude of the new Vassar Observatory. This Observatory had good glasses, but the mounting of both transit and equatorial offered much to be

desired. And one of the good things accomplished by Miss Mitchell during her professorship at Vassar was the improvement of the equatorial both in its glass, which was recut by Clark, and in its mounting. The final value of latitude adopted was secured by observations with a zenith telescope supplied by the U. S. Coast Survey. The final longitude determination was made by electric connection with Cambridge. Miss. Mitchell's observations with the equatorial were now mainly directed to Jupiter and Saturn. Several of her papers were published in Silliman's Journal. When photography became valuable in its application to the study of the solar surface, Miss Mitchell constructed at her own expense the necessary apparatus for photographing the sun, and trained her students to take these photographs. Miss Mitchell was associated with the expedition to Burlington, Iowa, made under the direction of Professor Coffin, Superintendent of the Nautical Almanac, for the purpose of observing the total solar eclipse of August 7th, 1869. Her report of this eclipse is contained in Professor Coffin's general report, published several years later. Again in 1878 she formed a party of her own for observing the solar eclipse of that year. Her station was then at Denver.

Miss Mitchell held the chair at Vassar until close upon her seventieth year. She then resigned, feeling the encroachment of years, and retired to Lynn, Mass., where she had been living at the time of her summons to Vassar. She planned to mount again her five-inch telescope and resume in a leisurely way her work upon double-stars. But health and strength steadily failed. She died on June 28th, 1889.

Professor Mitchell's influence as a teacher was of the highest order. It was helpful and stimulative. Vassar College has owed much to her. Her extended reputation added to its early success, and her force of character was a bulwark of strength in its initial days, when its object met but a partial public sympathy and its position was still insecure.

A VISIT TO SLOUGH.

D. W. EDGECOMB.

For The Messenger

The yearly visitors to Windsor Castle may probably be numbered by hundreds of thousands. Those who go by the Great Western railway leave the main road at Slough, and cross the Thames upon a curved line of rails, which reveal as you approach, the long walls and lofty towers of the Castle.

A few travelers, animated by different feelings from those of the great majority, turn in the opposite direction and seek the quiet churchyard of Stoke Poges, where, amid the many mouldering heaps that lie in that peaceful spot, they may sit beside the grave of the poet Gray, beneath the yew tree's shade. But it is rare that a traveler stops at Slough itself, and reveals to those about the station the bent of his mind or his occupation, by inquiring the way to the Herschel house, or the place where the great telescope once stood.

There is probably no spot in the world more interesting to astronomers of every grade, whether professional or the youngest amateur, the makers or the users of telescopes, than the house and garden which are associated with the life, labors and discoveries of Sir William Herschel. It is difficult to express the gratification one feels whose admiration of Herschel has been growing almost from his school boy days, and who finally finds himself standing before the modest house where he lived. It stands close to the street, in a pleasant part of the town, a few minute's drive from the station, and would seem to afford, even now, all the quiet and seclusion an astronomer could desire.

It has the name "Observatory House" upon the gate-post in accordance with a very pretty custom among the English people of giving names to their houses especially in the smaller towns, and the suburbs of the larger ones. Every one will be pleased to know that after having been in the possession of others for many years, the house is now again occupied by members of the family, the children of Sir John Herschel; and the pleasure of a visit is greatly enhanced by their kind and hospitable reception and their evident enjoyment of the interest manifested by the visitor.

Upon making known our errand, we are asked to enter the house, and find ourselves in a little reception room, or hall. Here our attention is at once attracted by a fine specimen of the Herschel six-inch telescope, the size most used by himself, and of which he made so many for others. It is of mahogany, very neatly finished, with octagonal tube, and the rather cumbersome framed stand with which, I believe, all the telescopes of this size were furnished. The instrument, with the exception of the mirror, was probably the work of his brother Alexander. The polish of the mirror is still good, and the flat and eye-piece holder are in perfect working order. The adjustment for focus in this instrument is made by sliding a brass plate, which carries the flat-arm and eye-tube up and down the main tube between guide pieces, so that both flat and eye-piece move together towards or away from the great mirror.

One can hardly resist the wish to try its performance upon some of Herschel's own objects,—Castor, or α Herculis, or η Coronæ, or the Debilisima. These latter Herschel could not see with his six-inch mirrors, but one can hardly doubt that now they would be revealed by one of them. And then the question would be, have the stars grown brighter, or have the eyes of modern observers, by some kind of evolution, and under the spur of practice, competition, or desire, grown more sensitive?

After a loving inspection of this instrument, our host asks us to turn, and there, on the other side of the room, partly concealed by flowers and a bunch of bracken from the "Burnham Beeches," to which he has lately made an excursion, shines the broad face of the speculum of the "forty-foot" telescope. We should know it anywhere. We knew that it was sealed up within the tube by Sir John Herschel, upon the merry occasion in 1839, when the tube was lowered to the ground and placed horizontally across the circle occupied by the mounting; and that, before the mirror was finally replaced, a long table was arranged within, at which all the little ones feasted; and then, each provided with a hammer, they "made the old telescope rattle and ring," all as described in Newcomb's "Popular Astronomy." But we now learned that some years afterwards a great tree fell across and broke the tube, but fortunately without injuring

the speculum. Some ten or twelve feet of the tube was then cut off and taken to one side of the garden, and carefully placed upon a portion of the original supports, while the mirror was brought into the house and securely suspended by an iron ring or strap, within the recess in the wall of the reception room where we then saw it. Our host was one of the "little ones" who feasted in the great tube with the happy party of 1839, and remembers well the racket made by their hammers, no small share of which he claims to have contributed.

And there is the great mirror, with its three-quarters of a ton of metal. Its surface is bright, but plainly not from the original polish. A network of fine scratches plainly shows that hands far from having any claim to optical skill have been at work But a practiced eye may readily determine what its original surface was It had undoubtedly a high and brilliant luster. Here and there a short scratch, with edges rounded by subsequent polishing, reveal the accidental work of stray bits of emery while under the hands of its maker, and suggest to the mind the vexation with which he viewed them after perhaps long hours of work, which he hoped would leave him a perfect surface. But there were only a few of these, while the great casting was a most excellent one with scarcely a pit or blemish in its whole area. Only those who have cast, ground, and polished mirrors of speculum metal, even of small dimensions, can fully appreciate the herculean nature of the task thus accomplished.

Probably a somewhat imperfect figure prevented the performance that its great size gave hope of, and explains the meagre reports of the appearance of objects seen by it, except where light alone was required. For even inside the marginal inch, not measured in the well known statement of its dimensions, a practiced eye, again, may plainly see that the edge is flattened or rounded, denoting over correction, and good definition could probably only be obtained by the use of a rather broad diaphram.

But the garden now remains to be visited, and with unabated interest, we pass to the rear of the house and step out upon the historic ground. A quadrangle presents itself measuring perhaps seventy-five by two hundred feet, surrounded by a neatly trimmed hedge, and covered with

smooth grassy sod, of that lovely rich green which, even in November, delights the eye of the American visitor to England. Smooth, except that nearly in the center is a square block of cut stone, upon which rests a disc of iron, the grinder for the great mirror. About this a ring of gently heaped earth indicates the foundation of the circular bed upon which the mounting revolved, with its spars and braces, its cross-bars, platforms and hoisting tackle.

It is just a hundred years since the great telescope was completed as signaled by the discovery of Enceladus. An upper story has been added to the house, but its lower part with the garden and its surroundings have scarcely changed. As we stand within the grass grown circle, the remark of the French astronomer comes vividly to mind: "There is no spot in the world where so many astronomical discoveries have been made as in that little garden at Slough."

It is a pleasant room in the house, the windows of which look out upon the garden; and at one of these the gentle sister of our guide and host appears, enjoying the pleased interest with which we examined the place and all that it contains; and it is not at all difficult to trace in her features a resemblance to her illustrious aunt, the loving companion of the labors of him who made the place historic.

Far above the roof of the house must have towered the mass of timber and the black tube suspended in the midst of it. The creaking of blocks, and the heavy rumble of the wheels upon the rails of the great circle, as the instrument was slowly raised, lowered or swung in azimuth, must have been a familiar nightly sound here a hundred years ago.

The speculum end of the tube, neatly painted and well-preserved, stands at one side. It is a substantial piece of iron work, well fitted to sustain the weight of the speculum, and if the whole instrtment was of similar workmanship, there were weight and strength sufficient.

At one corner of the garden stands the little house used by Sir William and his sister as the manuscript or computing house. It is unchanged, and one goes almost reverently into the principal room, the windows of which also look out upon the garden, and from which the telescope was in full view. Here in the quiet hours the patient sister sat, writing as the words of her brother came to her ears describing now

a nebula or a cluster, now the colors of a double-star, or perhaps giving the number of a count of a field of stars; intermingled, we cannot doubt, with expressions of astonishment, wonder, or delight, at the magnificent scenes that continually presented themselves to his sight Perhaps it is an August night, and portions of the Milky Way in Cygnus or Sagitarius are sweeping across the field; or it may be in the frosty air of a winter evening, as the glories of Orion or Gemini stream upon his vision, flashed from the upturned face of the great speculum.

In a rear room of the computing house are tools used by Sir William, Alexander, and Sir John Herschel, and in an upper room is preserved a part of the polishing apparatus for the four-foot speculum. It is the segment and arm for grasping and rotating the polisher, as figured in Sir John Herschel's book on the "Telescope."

Here, as he worked, the astronomer grew old, and saw the long night approach in which there is no observing. With what regret must he have felt the slow increasing weight of years, and, with the consciousness of so much yet remaining to be seen, how sadly as he climbed into the little observing house at the mouth of the great tube, must he have thought, that soon he would turn his eye from the eyepiece and his hand from the adjusting screw for the last time.

Here, as a child Sir John Herschel played and climbed about the mechanism of the great telescope, and here he began the labors which so fitly supplemented those of his father. Here he prepared the mirrors with which his observations at the Cape of Good Hope were made After his return he settled in Kent, but the Slough estate was retained, and four children, two sons and two daughters, have now made it their permanent home. Astronomers may be assured of a cordial and kindly welcome. Two were at home on the day of our visit, Colonel A. S. Herschel, and a sister; both were born at the Cape of Good Hope, and their earliest recollections are associated with the astronomical work of their father. The eighteen-inch mirrors used for the Cape observations are in possession of one of the sons, and are closely sealed for preservation.

As we left the house the wind from the south brought

to our ears the faint notes of a bugle from the walls of Windsor Castle. One can but feel grateful to one occupant of that royal keep, the monarch who could find time, even while devising plans for uncivilized warfare upon his rebellious subjects in America, or for thwarting the wishes and interests of the people of London, to honor himself and his reign by the aid given to the humble musician of Hanover, compared with whom Pitt and Burke and Fox and "all the king's counsellors" sink into insignificance. One can imagine the vexation with which Herschel might receive, on some clear night when he hoped for a period of uninterrupted observation, a gang of cavaliers from the Castle, who thought they must imitate the king by patronizing the great telescope and its maker.

Nor could we forbear the comparison between the enjoyment our visit had afforded, and that of the police-conducted assemblage that is permitted hourly to gaze upon the royal trappings of the state apartments of Windsor.

LONDON, Dec. 15, 1889.

LETTER FROM THE SUPERINTENDENT OF THE NAVAL OBSERVATORY.

I have the honor to acknowledge the receipt of your letter of the 6th instant, in which you quote from a communication from "the Director of one of our prominent Observatories" the following: "The Superintendent of the Naval Observatory takes the position that he is bound to furnish time signals from the U. S. Naval Observatory to the Western Union Telegraph Company. If the Company uses these time signals to crush out private Observatories it is something which the superintendent cannot help, and for which he is not responsible."

As Professor Pritchett is the only Director of an Observatory with whom I have ever had any correspondence or held any conversation on this matter, there can be no doubt that your information comes directly or indirectly from him. In either case I feel justified in sending you the entire correspondence between him and myself (inclosures marked A, B, and C), for it shows precisely what I wrote, and from it as a whole just conclusions can be drawn.

Any fair-minded man will conclude from my letter of Aug. 27, 1889, that after reading the circulars issued by the Western Union Company, I declared that I could not, on the evidence presented, dispute a right which had been acquired long before my connection with the Naval Observatory. My letter invites the production of proofs to substantiate assertions made by Professor Pritchett, of which those circulars gave no evidence, and declares a purpose to make proper use of such proofs. It goes further; it leaves entirely to the will of Professor Pritchett whether or not his communication shall be made the basis upon which I could institute an investigation of the matter. What more could any one have done under the circumstances? From Professor Pritchett's reply it is manifest that he was satisfied, for the time being, at least, with the terms of my letter, and did not desire to press the matter of the Western Union Company's interference with his business.

This is the only instance to which my attention has been officially called of the aggressions of the Western Union Telegraph Company upon any Observatory; and the correspondence in this case speaks for itself.

While the significance of the clause in my letter, "The right of the Western Union Company to so use our daily signal I cannot dispute; it rests upon an arrangement in existence long before I came to the Observatory," was fully understood by Professor Pritchett, who is quite familiar with the steps that have led to the existing arrangement, it may not be so to others. I shall therefore refer as briefly as possible to the history of this arrangement. From the disconnected correspondence on the subject at hand and from information given by officers who were connected with the Observatory when the arrangement was entered into, I gather the following:

The Western Union Telegraph Company has been receiving Observatory time since about 1863. In December, 1876, the Superintendent of the Observatory formally proposed to the Vice President of the Western Union Company that time should be sent to a prominent jeweler in Leavenworth who had made written application to him for it, and also for the use and convenience of large cities. It was not until after considerable delay, and importunity on the part of Observa-

tory officials, that the Western Union Company consented to the arrangement. The time service then had little or no commercial value, and it is doubtful whether the Company was remunerated for its trouble and expense, certainly not to any great extent when it is considered that exchange longitude signals (including the service and time of Western Union officials), signals to time-ball station and other public points were sent without charge. On this point, however, I have no definite information and only suggest a probability.

Under these conditions it can be easily understood that I was not willing to ask the Navy Department (for I have not the authority to do so myself) to discontinue a long established practice without some kind of investigation into alledged abuses of it, and this investigation was not desired by one of the most largely interested persons whose rights, it is claimed, are threatened.

The correspondence between Professor Pritchett and myself shows—

1st. That I was willing upon definite evidence to act in the matter complained of.

2d. That I was willing to accept the letter of Professor Pritchett as a sufficient basis upon which to open an investigation.

3d. That Professor Pritchett was unwilling to assume the responsibility for the charges he made.

4th. That Professor Pritchett (perhaps not directly but by inference), asked *me* to assume a responsibility that *he himself* wished to evade.

5th. That the only complaint that has ever reached me in proper form was dropped at the request of the complainant.

The attitude which this Observatory has assumed towards the Western Union Company as transmitters of time is clearly shown in a letter to Messrs. John Bliss & Co. I inclose a copy of it marked D. It was written in reply to an application from Messrs. Bliss & Co. for a table of corrections during a long interval of bad weather. It emphatically points out that this Observatory does not recognize any relation with the Western Union Company's business, and that it declines to furnish information concerning signals transmitted by that company. So much for your letter.

I now come to an article published in the December number of THE SIDEREAL MESSENGER, headed "Observatory Local Patronage Threatened."

In it it is stated that "the general officers of this commercial company (which we will now name as the Western Union Telegraph Company) interviewed the Superintendent of the U S. Naval Observatory, and sought and obtained of that officer, as they say, certain definite contract relations by which the telegraph company should have the privilege and right to use the time of the U. S. Naval Observatory for its own uses in commercial sale and barter." By the insertion of the words, "they say," you place the responsibility of this assertion upon the officers of the Western Union Telegraph Company. From whatever source it comes it is absolutely without foundation. The present superintendent of the Naval Observatory (and he is, from the context, the one meant), has never had any correspondence, interview, or communication of any kind with an official of the Western Union Company, on this or any kindred subject, or branch of it, except to call for circulars as mentioned in my letter to Professor Pritchett, the following being the whole of the language used: "Please send me copies of all circulars of the company relating to the distribution of time, in which the Naval Observatory is mentioned or referred to and oblige," etc.

In this connection I beg to return to your letter of Dec. 6, and to invite a comparison of the following paragraph from it with the language of your published article. You write, "While in conversation with a Vice-President of the Western Union Telegraph Company a few days ago, he stated to me that his company was under contract relations with the National Observatory by which they were entitled to use the Washington time throughout the United States for such purposes as they wished in their commercial business." From the following sentence in the published article—"This is no secret on the part of the telegraph company, for the writer has heard a Vice-President of the company very freely speak of the matter"—it is fair to presume that the conversation with the official alluded to in your letter is the source of information upon which your article is based. Now according to your letter the Western Union official said that a

contract relation exists between this Observatory and his company and nothing more. While the old arrangement by which the Western Union Company receives our time signal cannot be called a contract, it is the only agreement with the Observatory that exists, and in the absence of any proof that the Western Union official is not honest and truthful, it is reasonable to assume that he alluded to it. If he did, you have not fairly quoted him, but have put upon his language an interpretation which is stretched far beyond the limits of truth. This is an issue between yourself and the Western Union official.

The article further states—"Whatever arrangements the Superintendent of the United States Naval Observatory entered into with the telegraph company named, by which it was deemed wise to permit this kind of an attack to be made on the local financial support of the Observatories of the country, is not apparently very easy to find out." It also speaks of "this rather extraordinary transaction between a government official and a private telegraph company by which the rights and interests of educational institutions of the land are put in hardship with the prospect of financial loss, to increase the business of a private telegraph company," etc. For these two paragraphs you seem to assume the responsibility.

As any arrangement of a public and official nature could very easily be found out, it must be inferred that you intend to imply that some private arrangement has been entered into between myself and the Western Union Company.

This implication and the inferences to be drawn from it, as well as from the last above quotation from your article, are absolutely false. I have no connection of any kind with, nor interest in, the Western Union or any other time company; nor have I had such connection or interest.

In conclusion I must say that this positive denial of the unwarranted and unjust reflections upon me will be my last communication upon the subject. The controversy which has inspired your uncalled for attack upon me is a purely business fight between persons or corporations engaged in transmitting time for a money consideration, with which I have nothing to do; and although all my sympathies are with the Observatories whose revenue from time service is

devoted to Observatory purposes, I cannot be drawn into the conflict. The efforts which I have made (and successfully in most cases) to use this Observatory in forwarding the interests of other Observatories with which I have had relations will, I believe, be a sufficient defense against any further attempts on the part of your paper to create the impression that I am inimical to sister institutions.

You are at liberty to make this letter public, *with this positive restriction*, that no part of it shall be published unless every word, including inclosures, is embraced in the same article. Indeed it is my wish that you do so, and such a course seems the only fair one open to you. The position in which your article places me before your readers (among whom I have many friends) is sufficient excuse for the plain terms I have used.

A

ST. LOUIS, Aug. 8, 1889.

Captain R. L. Phythian, U. S. N.,

Supt. U. S. N. Observatory, Washington, D. C.

DEAR SIR: I beg to ask your kindly offices in the following matter.

The Western Union Company has recently served notice upon all railroads using our time that they would be expected to take time signals hereafter from Washington through the Western Union Company. In this notice the company assumes to control the government time service, for which it alone contracts, and alludes to the service maintained by the other Observatories as a rival service. The company also attempts under its contracts with the railroads to prevent us from running our wires into the offices of such roads as desire to retain the present arrangement.

The Western Union Company also announces that time signals will be furnished from the Naval Observatory at any hour desired and in accordance with the exact programme we have been using.

I write to you in the matter because I am led to believe that a request from you to the Western Union Company to limit the use of the Naval Observatory signals to the part of the country not already furnished with time signals would have great weight not only with them but also with the railroads themselves. I feel quite sure that if you were aware of the manner in which the National Observatory is being placed before the country in the matter you would be glad to correct some of the impressions that are being sent out.

The way in which the company is to operate in some of the cities will result, I am sure, in bringing more or less discredit on the Observatory time service. "Master clocks," as they are called, are to be established at various places from which time signals are to be sent. As these signals will purport to give the Observatory time the Observatory is certain to come in for the credit of the errors which are sure to come about in any such system.

As the matter is one of very great importance to us I trust that you will be willing to take such action as I have requested.

I am very respectfully,

H. S. Pritchett,

Director Observatory.

B.

U. S. Naval Observatory, Washington, Aug. 27, 1889.

Professor H. S. Pritchett,

Observatory of Washington University, St. Louis, Missouri:

Dear Sir: Upon the receipt of your letter of Aug. 8, 1889, I wrote to the Western Union Telegraph Company, asking for copies of all circulars issued by them in which the Naval Observatory is mentioned. They have sent me three, viz:

1st. Catalogue of self-winding synchronized clocks as furnished by the Self-Winding Clock Company, New York.

2d. Self-winding Clock Company's synchronized clocks and daily time signals.

3d. Synchronized self-winding clocks, corrected daily by telegraphic time signals from the Naval Observatory, Washington. D. C. Also a 4th which, with a very slight modification of title, is the same as No. 2.

In these circulars it is announced that clocks will be corrected daily by signals from the Naval Observatory. The right of the Western Union Company to use our daily signals I cannot dispute; it rests upon an arrangement in existence long before I came to the Observatory and any attempt on my part to restrict them to prescribed limits would be futile.

I presume that the term "rival service" is intended to express the relation between the Western Union Company as transmitters of time, and other persons engaged in the same business. But if you can point out to me that the expression has been used to convey the impression that this Observatory can be regarded in the light of a rival to any other Observatory in transmitting time, I shall be greatly obliged to you for the information and shall make proper use of it.

Again I shall be obliged to you if you will indicate how I may learn that the Western Union Company has made any other pledge for this Observatory than to transmit daily noon signals (except in case of failure at noon when a later signal will be sent).

Furthermore, I would esteem it a great favor to be informed of any arrangement by which time transmitted by "master clocks," or by any other means than our noon signals, is to be designated as "Washington Observatory Time." I would also thankfully receive information that the Western Union Company has issued any other circulars than those enumerated above, in which this Observatory is mentioned.

I have regarded your letter of August 8 as confidential as far as the Western Union Company is concerned, and have not felt at liberty to acquaint that company of its contents. If, however, you are willing that the letter shall be treated as official, I shall call upon the General Manager of the Western Union for an explanation of the unwarranted use of the name of the Observatory which you assert is being made. Very respectfully,

R. L. Phythian, Captain, U. S. N., Superintendent.

C.

Captain R. L. Phythian, U. S. N.,
Supt. U. S. N. Observatory, Washington, D. C.

DEAR SIR: I beg to acknowledge the receipt of your very kind letter of Aug. 27, which I have just received on returning from a month's absence in the West.

The announcements to which I particularly referred were made by local canvassers for the Western Union Company and by the local superintendent in personal letters to railroad managers which were shown to me but of which I, of course, have no copy. These letters, of course, urged the managers of roads using our service to change and promised a service at the same hour and sent in accordance with the programme we use. What I particularly desired to know was whether such signals would be sent from the Observatory at various hours.

Since writing to you, and a few days before my departure for the West, I had an interview with the Western Manager of the telegraph company together with certain representatives of the railroads, which gives me reason to expect that the matter will be arranged in a satisfactory manner. I shall therefore ask that you will consider both my former letter and the present one as personal communications.

Thanking you again for your cordial reply, I am,

Very respectfully yours,
H. S. PRITCHETT.

D.

NAVAL OBSERVATORY, WASHINGTON, Nov. 2, 1889.

DEAR SIRS: Your letter of October 29th has been received and its contents carefully considered. It is observed that a comparison, the nature of which I do not understand, has been made between the (so called) Observatory signals and a Western Union clock, also that the record of Mr. Hamblet's chronograph has played some part in determining corrections to signals received by you. In short, it is apparent that you have been receiving what purports to be Naval Observatory time through devices over which we have no control, and whose use we have at all times discouraged. Under these circumstances I must decline to furnish you with the corrections asked for.

If you will arrange to receive our signal on a chronograph (or in any other approved manner), in your own establishment so that it will be recorded by the impulse sent from this Observatory, without the intervention of transmitting clocks, or other devices, I shall gladly send you from time to time a table of such small errors as occur during long intervals of weather unfavorable for observation, and of the small corrections to the clock's rate found by back interpolation. In other words, I will supply you with corrections to our *direct* signal which will give you time for which we are willing to be responsible.

Very respectfully,
R. L. PHYTHIAN,
Captain U. S. N., Superintendent.

Messrs. John Bliss & Co.,
128 Front Street, New York, N. Y.

OBSERVATORY LOCAL PATRONAGE.

In reply to the foregoing very remarkable communication THE MESSENGER does not need to say much now. That portion of it referring to Professor Pritchett he will doubtless answer when the time comes. We have obtained his consent to publish his personal and private letters, so as fairly to meet the singular demand of the Superintendent of the United States Naval Observatory. It should also be said that our private letter to the Superintendent of Dec. 6, asking if a certain statement of his position in regard to local observatories was correct or not, portions of which he hastens to print, had not the remotest reference to the article above referred to, for that article was in print before the statement of his position was known. Further, the Superintendent did not *know* who had made the statement of his position, and yet he answers it depending on, and using, private and personal letters in self-defence. This is a piece of official courtesy that THE MESSENGER is very willing to give full credit for, to the Superintendent, not only because he wants it, but also because he demands it accompanying his demands in a private letter with serious threats if we do not publish "every word" just as he had written it. The Superintendent is evidently much troubled about something.

Now we want to say to the Superintendent that we are not frightened by his threats, nor are we satisfied with the logic of his answer to our article. Attention is called to his replies to points at issue.

1. We have said there are definite contract relations existing between the Western Union Telegraph Company and the Superintendent of the United States Naval Observatory for the Washington time, for the telegraph company's uses in commercial sale and barter. The Superintendent says this statement is "absolutely without foundation;" but does admit that an "*arrangement*" exists by which the Western Union uses the Washington time signals. Fine distinction! Not a contract but an "*arrangement*." Is the Superintendent driven in his answer to play with words? Whatever he may say about a contract or an "arrangement," a general officer of the telegraph company says there is a contract. Now, in fact, it does not matter at all

whether this contract is in written or verbal form, the telegraph company is now using its privileges to destroy existing local support for local observatories, and we have reason to believe that the Superintendent knows the main facts in the case and does not choose to interfere.

2. How has this late interest in spreading the Washington time all over the country come about?

We call the attention of our readers to the printed proceedings of the General Time Convention held in New York City April 11 and October 10, 1889. At both of these meetings Commander Brown, from the United States Naval Observatory was present. At the first meeting he made extended remarks before the convention urging the general use of the Observatory time, and suggesting that if railway officials needed information, and could not visit Washington doubtless on application some one would be sent to put them in possession of that which they desired to know. At the October meeting Commander Brown reported that he was "prepared to give the time" (meaning the Washington time from the Naval Observatory) "at any hour between 10 o'clock A. M. and midnight that may suit any member of the convention who may ask for it. Before 10 o'clock they have to check up their operations" (observations, probably,) "so as to give the time properly," etc. Why is Commander Brown sent out to these meetings of railway officials? Why is he offering the Washington time and pledging that the Western Union Telegraph Company will transmit this time to any railroad company, using the telegraph company's wires entirely free of charge? Did the Superintendent of the Naval Observatory know anything about this, or was it an "arrangement" made before the time of his administration which began in 1886? That October printed report says (p 23) that arrangements have been perfected between the United States Observatory at Washington and the Western Union Telegraph Company, by which standard time can be obtained by any (railroad) company reached by the wires of the telegraph company, *without charge* (italics ours), by application to the latter. This plainly shows the position of the Superintendent of the United States Naval Observatory.

3. There are some other steps in this interesting program that we can now only refer to for want of space. The fol-

lowing queries will suggest them: When was the salary of the instrument maker to the Naval Observatory raised? How many times, and by whose recommendation? When did this instrument maker sell the rights of his patent electrically controlled clocks to the Bedford Clock Company of New York City? How much money was paid for the general control of this patent? Were there deferred payments of considerable amounts? If so were those deferred payments made dependent in any way on the use of the Washington time? These are some of the queries that interest local Observatories that have honestly earned and are now enjoying a local patronage by furnishing standard time to local railway companies, at their own figures. This local patronage is now menaced by the united action of the United States Naval Observatory and the Western Union Telegraph Company. The letters already received from the oldest and the most prominent Observatories in the United States plainly indicate that THE MESSENGER's word of advice and alarm are timely and worthy of immediate and serious attention.

ON THE STABILITY OF THE RINGS OF SATURN.*

GEORGE W. COAKLEY.†

For THE MESSENGER.

The satellites of Saturn are very much nearer to the rings than the sun and planets are; and the *difference of their distances* from Saturn's centre, and from the different parts of the ring, bears too great a ratio to their mean distances to allow us to take their action on the nearest and farthest points of the ring as a good approximation to their whole disturbing action. It becomes necessary, therefore, to endeavor to take account of the sum total of all their disturbing forces on each half of the ring, in order to estimate their effect in removing the ring's centre from that of Saturn.

Each ring is very thin and flat, and also of narrow breadth when compared with its diameter; and hence it may be supposed to be composed of a number of concentric

* Continued from p. 11, No. 81. † Professor of Astronomy in the University of the City of New York.

circles. If the disturbing action of one of the satellites upon one of these narrow circles be determined, it will make known the like action on each of the circles of which the ring is supposed to consist; and therefore determine the action of the satellite on the whole ring. This is, in fact, La Place's mode of treating the action on the ring. Let us take the circular ring situated at the middle of Saturn's exterior ring for the special subject of investigation. The centre of this circular ring is taken at first to coincide with that of the planet, and its radius is R = 2.2115, the equatorial radius of Saturn being the unit. Let A = the mean distance from Saturn's centre, in terms of the same unit, of one of his satellites, Titan for example.

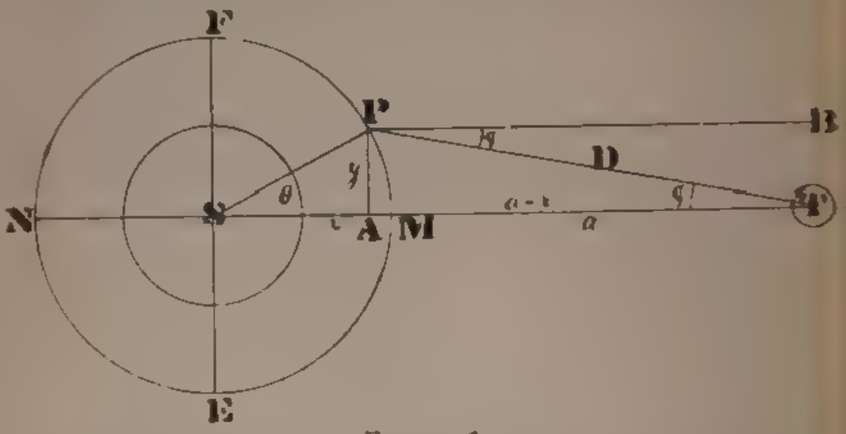

FIGURE 1.

In Fig. I. above, let S be Saturn's centre, and that of the ring; P, any point on the circumference of the middle circle of the exterior ring; SP = R = 2.2115 = the radius of this circle, in terms of Saturn's equatorial radius. Let the inner circle represent Saturn, and T be the position of *any satellite*, Titan for example.

Let $ST = a$ = the mean distance of the satellite, $SA = x$, $AP = y$, the angle $ASP = \theta$, measured as an arc on the equator of Saturn; let $PTS = TPB = \varphi$; $PT = D$ = the distance of the point P from the satellite. The element of the circumference at P is $Rd\theta$; and if m = the mass of the satellite at T, its attraction on the element at P is $\frac{m \,.\, Rd\theta}{D^2}$. If

this force be resolved in the direction of PB, parallel to ST, it will be $\frac{m \cdot Rd\vartheta}{D^2} \cos\varphi$. The acceleration in the direction of PB will be $\frac{m}{D^2}\cos\varphi$. The acceleration impressed upon Saturn by the satellite, in the direction ST or PB, will be $\frac{m}{a^2}$. Hence the *difference of acceleration* on the element at P, and on Saturn, is $\frac{m}{D^2}\cos\varphi - \frac{m}{a^2}$. This is the force that solicits the element at P away from Saturn's centre, in a direction parallel to ST. There are other components of the satellite's attraction; but they have little or no influence in disturbing the centre of the ring in reference to that of the planet. Hence it is not necessary to consider them. To obtain the sum total of all the disturbing forces, like $\frac{m}{D^2}\cos\varphi - \frac{m}{a^2}$, acting at every point, P, of the semicircle EPF, and at every point of the semicircle, ENF, it is only requisite to multiply the force $\frac{m}{D^2}\cos\varphi - \frac{m}{a^2}$ by $Rd\vartheta$, the element at P, and then integrate, in reference to the variable ϑ, first between the limits $\vartheta = -\frac{\pi}{2}$ and $\vartheta = +\frac{\pi}{2}$, and afterwards between the limits $\vartheta = +\frac{\pi}{2}$ and $\vartheta = +\frac{3\pi}{2}$. Let f_1 denote the first summation, and f_2 the second. Then f_1 will denote the total force of the satellite in drawing away the nearer half of the circular ring from Saturn; but, as f_2 will be negative, showing that the remote half of the ring is virtually driven away from Saturn, the absolute amount of this action will be denoted by $-f_2$, and their ratio will be expressed by $\frac{f_1}{-f_2}$.

But $SA = x = R\cos\vartheta$; $AP = y = R\sin\vartheta$; $AT = a - x = D\cos\varphi$; $AP = y = D\sin\varphi$. Hence $D^2 = (a-x)^2 + y^2 = a^2 - 2ax + x^2 + y^2$.

$$\therefore D^2 = a^2 - 2aR\cos\vartheta + R^2 = a^2\left\{1 - 2\frac{R}{a}\cos\vartheta + \frac{R^2}{a^2}\right\}$$

$$\therefore D = a\left\{1 - 2\frac{R}{a}\cos\vartheta + \frac{R^2}{a^2}\right\}^{\frac{1}{2}}$$

$$\cos\varphi = \frac{a-x}{D} = \frac{a - \mathrm{R}\cos\vartheta}{a\left\{1 - 2\frac{\mathrm{R}}{a}\cos\vartheta + \frac{\mathrm{R}^2}{a^2}\right\}^{\frac{1}{2}}}$$

$$= \frac{1 - \frac{\mathrm{R}}{a}\cos\vartheta}{\left\{1 - 2\frac{\mathrm{R}}{a}\cos\vartheta + \frac{\mathrm{R}^2}{a^2}\right\}^{\frac{1}{2}}}$$

Hence $\frac{m}{D^2}\cos\varphi - \frac{m}{a^2} = \frac{m}{a^2} \cdot \frac{1 - \frac{\mathrm{R}}{a}\cos\vartheta}{\left\{1 - 2\frac{\mathrm{R}}{a}\cos\vartheta + \frac{\mathrm{R}^2}{a^2}\right\}^{\frac{3}{2}}} - \frac{m}{a^2}$

Let $\frac{\mathrm{R}}{a} = \beta$, which may be treated as a *constant*, with a different value, however, for each satellite, since it will answer the purpose of this investigation to treat the orbits of Saturn's satellites as *circles*, each with a different radius, a.

Hence

$$\frac{M}{D^2}\cos\varphi - \frac{m}{a^2} = \frac{m}{a^2} \cdot \left\{(1-\beta\cos\vartheta)(1-2\beta\cos\vartheta+\beta^2)^{-\frac{3}{2}} - 1\right\}. \quad \text{(A.)}$$

Since β is generally a small fraction, less than unity, the expression (A) may be developed in a series of converging terms arranged according to the successive powers of β. It may then be multiplied by $Rd\vartheta$, and the several terms be integrated as far as requisite to get a good approximation to the ratio $\frac{f_1}{-f_{,}}$.

The development of $(1 - 2\beta\cos\vartheta + \beta^2)^{-\frac{3}{2}}$ is

$$1 + 3\cos\vartheta \,.\, \beta - \tfrac{3}{2}(1 - 5\cos^2\vartheta) \,.\, \beta^2 - \tfrac{5}{2}(3\cos\vartheta - 7\cos^3\vartheta) \,.\, \beta^3$$
$$+ \tfrac{15}{8}(1 - 14\cos^2\vartheta + 21\cos^4\vartheta) \,.\, \beta^4 + \tfrac{21}{8}(5\cos\vartheta - 30\cos^3\vartheta + 33\cos^5\vartheta) \,.\, \beta^5$$
$$- \tfrac{7}{16}(5 - 135\cos^2\vartheta + 495\cos^4\vartheta - 429\cos^6\vartheta) \,.\, \beta^6$$
$$- \tfrac{9}{16}(35\cos\vartheta - 385\cos^3\vartheta + 1001\cos^5\vartheta - 715\cos^7\vartheta) \,.\, \beta^7$$
$$+ \tfrac{45}{128}(7 - 308\cos^2\vartheta + 2002\cos^4\vartheta - 4004\cos^6\vartheta + 2431\cos^8\vartheta) \,.\, \beta^8 + \text{etc.}$$

Hence $(1 - \beta\cos\vartheta)(1 - 2\beta\cos\vartheta + \beta^2)^{-\frac{3}{2}} - 1 = 2\cos\vartheta \,.\, \beta$

$$- \tfrac{3}{2}(1 - 3\cos^2\vartheta) \,.\, \beta^2$$
$$- 2(3\cos\vartheta - 5\cos^3\vartheta) \,.\, \beta^3 + \tfrac{5}{8}(3 - 30\cos^2\vartheta + 35\cos^4\vartheta) \,.\, \beta^4$$
$$+ \tfrac{3}{4}(15\cos\vartheta - 70\cos^3\vartheta + 63\cos^5\vartheta) \,.\, \beta^5$$

$$- \tfrac{7}{16}(5 - 105 \cos^2 \vartheta + 315 \cos^4 \vartheta - 231 \cos^6 \vartheta) \,.\, \beta^6$$
$$- \tfrac{1}{2}(35 \cos \vartheta - 315 \cos^3 \vartheta + 693 \cos^5 \vartheta - 429 \cos^7 \vartheta) \,.\, \beta^7$$
$$+ \tfrac{9}{128} (35 - 1260 \cos^2 \vartheta + 6930 \cos^4 \vartheta - 12012 \cos^6 \vartheta +$$
$$6435 \cos^8 \vartheta) \,.\, \beta^8 + \text{etc.}, = \frac{a^2}{mR} \cdot \frac{df}{d\vartheta}.$$

The integral of the last equation, in reference to ϑ as the variable, gives:

$$\frac{a^2}{mR} \,.\, f = C + 2 \sin \vartheta \,.\, \beta + \tfrac{3}{4} (\vartheta + 3 \sin \vartheta \cos \vartheta) \,.\, \beta^2$$
$$+ \tfrac{2}{3} (\sin \vartheta + 5 \sin \vartheta \cos^2 \vartheta) \,.\, \beta^3$$
$$+ \tfrac{5}{64} (9 \vartheta - 15 \sin \vartheta \cos \vartheta + 70 \sin \vartheta \cos^3 \vartheta) \,.\, \beta^4$$
$$+ \tfrac{1}{20} (29 \sin \vartheta - 98 \sin \vartheta \cos^2 \vartheta + 189 \sin \vartheta \cos^4 \vartheta) \,.\, \beta^5$$
$$+ \tfrac{7}{256} (25 \vartheta + 105 \sin \vartheta \cos \vartheta - 490 \sin \vartheta \cos^3 \vartheta +$$
$$616 \sin \vartheta \cos^5 \vartheta) \,.\, \beta^6$$
$$+ \tfrac{1}{70}(53 \sin \vartheta + 639 \sin \vartheta \cos^2 \vartheta - 2277 \sin \vartheta \cos^4 \vartheta +$$
$$2145 \sin \vartheta \cos^6 \vartheta) \,.\, \beta^7$$
$$+ \tfrac{9}{16384} (1225 \vartheta - 3255 \sin \vartheta \cos \vartheta + 51590 \sin \vartheta \cos^3 \vartheta$$
$$- 136136 \sin \vartheta \cos^5 \vartheta + 102960 \sin \vartheta \cos^7 \vartheta) \,.\, \beta^8 + \text{etc.}$$

Hence, between the limits $-\tfrac{1}{2}\pi$ and $+\tfrac{1}{2}\pi$,

$$\frac{a^2}{mR} \cdot f_1 = 4 \,.\, \beta + \tfrac{3}{4}\pi \,.\, \beta^2 + \tfrac{4}{3}\beta^3 + \tfrac{45}{64}\pi \,.\, \beta^4 + \tfrac{29}{10}\beta^5 + \tfrac{175}{256} \,.\, \pi \,.\, \beta^6$$
$$+ \tfrac{58}{35} \beta^7 + \tfrac{11025}{16384} \,.\, \pi \,.\, \beta^8 + \text{etc.}$$

And between the limits $\tfrac{1}{2}\pi$ and $\tfrac{3}{2}\pi$

$$\frac{a^2}{mR} \cdot f_2 = - 4 \,.\, \beta + \tfrac{3}{4}\pi \,.\, \beta^2 - \tfrac{4}{3}\beta^3 + \tfrac{45}{64}\pi \,.\, \beta^4 - \tfrac{29}{10}\beta^5 + \tfrac{175}{256}\pi \,.\, \beta^6$$
$$- \tfrac{58}{35} \,.\, \beta^7 + \tfrac{11025}{16384} \,.\, \pi \,.\, \beta^8 - \text{etc.}$$

The two last equations may be more conveniently written

$$\frac{a^2}{4m\rho R} \cdot f_1 = 1 + \tfrac{3}{16}\pi \,.\, \beta + \tfrac{1}{8}\beta^2 + \tfrac{45}{256}\pi\beta^3 + \tfrac{29}{40}\beta^4 + \tfrac{175}{1024}\pi \,.\, \beta^5$$
$$+ \tfrac{58}{140}\beta^6 + \tfrac{11025}{65536}\pi \,.\, \beta^7 + \text{etc.}$$

$$-\frac{a^2}{4m\rho R} \cdot f_2 = 1 - \tfrac{3}{16}\pi\beta + \tfrac{1}{3}\beta^2 - \tfrac{45}{256}\pi \,.\, \beta^3 + \tfrac{29}{40}\beta^4 - \tfrac{175}{1024}\pi \,.\, \beta^5$$
$$+ \tfrac{58}{140}\beta^6 - \tfrac{11025}{65536}\pi \,.\, \beta^7 - \text{etc.}$$

Hence the ratio of f_1 to $-f_2$ is

$$\frac{f_1}{-f_2} = \frac{1 + \frac{3}{16}\pi.\beta + \frac{1}{8}\beta^2 + \frac{45}{256}\pi.\beta^3 + \frac{29}{40}\beta^4 + \frac{175}{1024}\pi.\beta^5 + \frac{58}{140}\beta^6 + \frac{11025}{65536}\pi.\beta^7 \,\&c}{1 - \frac{3}{16}\pi.\beta + \frac{1}{8}\beta^2 - \frac{45}{256}\pi.\beta^3 + \frac{29}{40}\beta^4 - \frac{175}{1024}\pi.\beta^5 + \frac{58}{140}\beta^6 - \frac{11025}{65536}\pi.\beta^7 \,\&c}$$

Let $A_1 = \tfrac{3}{16}\pi$, $A_2 = \tfrac{1}{8}$, $A_3 = \tfrac{45}{256}\pi$, $A_4 = \tfrac{29}{40}$, $A_5 = \tfrac{175}{1024}\pi$, $A_6 = \tfrac{58}{140}$, $A_7 = \tfrac{11025}{65536}\pi$. Then

$$\frac{f_1}{-f_2} = \frac{1+A_1.\beta+A_2.\beta^2+A_3.\beta^3+A_4.\beta^4+A_5.\beta^5+A_6.\beta^6+A_7.\beta^7 + \text{etc.}}{1-A_1.\beta+A_2.\beta^2-A_3.\beta^3+A_4.\beta^4-A_5.\beta^5+A_6.\beta^6-A_7.\beta^7 + \text{etc.}};$$

and $\log A_1 = \bar{1}.7701519$, $\log A_2 = \bar{1}.5228787$,
$\log A_3 = \bar{1}.7421224$, $\log A_4 = \bar{1}.8603380$,
$\log A_5 = \bar{1}.7298879$, $\log A_6 = \bar{1}.5781479$,
$\log A_7 = \bar{1}.7230486$.

Since $R = 2.2115$, and for Saturn's first satellite, Mimas, $a = 3.3$, hence $\beta = \frac{2.2115}{3.3}$,

$$\log R = 0.3446869$$
$$\log a = 0.5185139$$
$$\therefore \log \beta = \bar{1}.8261730$$

For the second satellite, Enceladus, $\log a = 0.6334685$
$\therefore \log \beta = \bar{1}.7112184$

For the third satellite, Tethys, $\log a = 0.7242759$
$\therefore \log \beta = \bar{1}.6204110$

For the fourth satellite, Dione, $\log a = 0.8325089$
$\therefore \log \beta = \bar{1}.5121780$

For the fifth satellite, Rhea, $\log a = 0.9777236$
$\therefore \log \beta = \bar{1}.3669633$

For the sixth satellite, Titan, $\log a = 1.3159703$
$\therefore \log \beta = \bar{1}.0287166$

For the seventh satellite, Hyperion, $\log a = 1.4281348$
$\therefore \log \beta = \bar{2}.9165521$

For the eighth satellite, Japetus, $\log a = 1.8088859$
$\therefore \log \beta = \bar{2}.5358010$

From the values of the logarithms of β, for the several satellites, together with the preceding values of $\log A_1$, $\log A_2$, etc., and the formula for $\frac{f_1}{-f_2}$ the following table has been computed:

		$\frac{f_1}{-f_2}$			$\frac{f_1}{-f_2}$
1st Satellite	Mimas	3.00321	5th Satellite	Rhea	1.32994
2d "	Enceladus	2.08252	6th "	Titan	1.13530
3d "	Tethys	1.74577	7th "	Hyperion	1.10262
4th "	Dione	1.51191	8th "	Japetus	1.04132

The summation of the series, to determine the ratio of f_1 to $-f_2$, has probably not been carried far enough to give a good approximation to this ratio for the first two satellites. But still it gives with sufficient accuracy the *character* of the disturbing action of these satellites upon the ring. This ac-

tion is of the same nature, though relatively larger, as that of the other six satellites. In the case of these last six satellites, the summation as far as the fourth power of β gives very nearly, or within one per cent, of the same values of $\frac{f_1}{-f_3}$ as that obtained by continuing the computation to the seventh power of β. All these results show that the action of the satellites is greater on the nearer half of the ring than on the remote half; and that they thus tend to draw the centre of the ring away from Saturn towards their own direction. But, *if the ring be liquid or fluid*, each satellite also tends to raise tides in the ring in the line of its action; greater, however, on the nearer half than on the remote half, *exactly in proportion to the excess of action that tends to remove the ring's center from that of Saturn.* This is one of the most important conclusions arrived at in reference to the stability of the rings. It will be found, I think, that their stability depends entirely upon this principle of the *relative tides* that the satellites and other disturbing bodies may produce upon the near and remote halves of a liquid or fluid ring.

How the stability of one of the rings may be determined by the tidal action of a satellite, or other disturbing body, is the next subject for investigation.

In Fig. 2 let S be the centre of Saturn, $SF = SH = 1 =$ his equatorial radius; and suppose the centre of one of his rings to be drawn away from that of Saturn to C, a very small distance, by the attraction of one of the satellites, or by the sun, or by one of the major planets. Let $Cl_1 = Cl_2 =$ the radius of the middle of the ring. Through S and C let a straight line be drawn, and let HSF be perpendicular to this line. Through S draw also the two straight lines AE, BD, including the angle ϑ, measured on the circumference of Saturn. Let $SA = R_1$, $SE = R_2$. The lines AE and BD intercept arcs, $AB = l_1$, and $DE = l_2$, on the middle circle of the ring, such that $l_1 = R_1.\vartheta$, $l_2 = R_2.\vartheta$. Let m_1 and m_2 be the masses of the segments AB and DE, cut off by the planes through AE and DE perpendicular to the plane of the ring. Also let a_1 and a_2 be the areas of the cross sections of these two segments respectively. Then if $\delta =$ the density of the ring in all its parts, the masses of these segments will be, $m_1 = a_1 l_1 \delta$,

$m_2 = a_2 l_2 \delta$. Hence, replacing l_1 and l_2 by their values, $m_1 = \vartheta\delta a_1 R_1$; $m_2 = \vartheta\delta a_2 R_2$.

The lines AE, BD, are supposed to be drawn at a small inclination, ϑ, to each other, but at any inclination to FH.

If $M =$ Saturn's mass, his attraction for the nearer segment is $\frac{M}{R_1{}^2}$ and the accelerative force of this segment on Saturn is $\frac{M_1}{R_1{}^2}$. Hence the whole accelerative force between Saturn and this nearest segment is $F_1 = \frac{M + m_1}{R_1{}^2}$

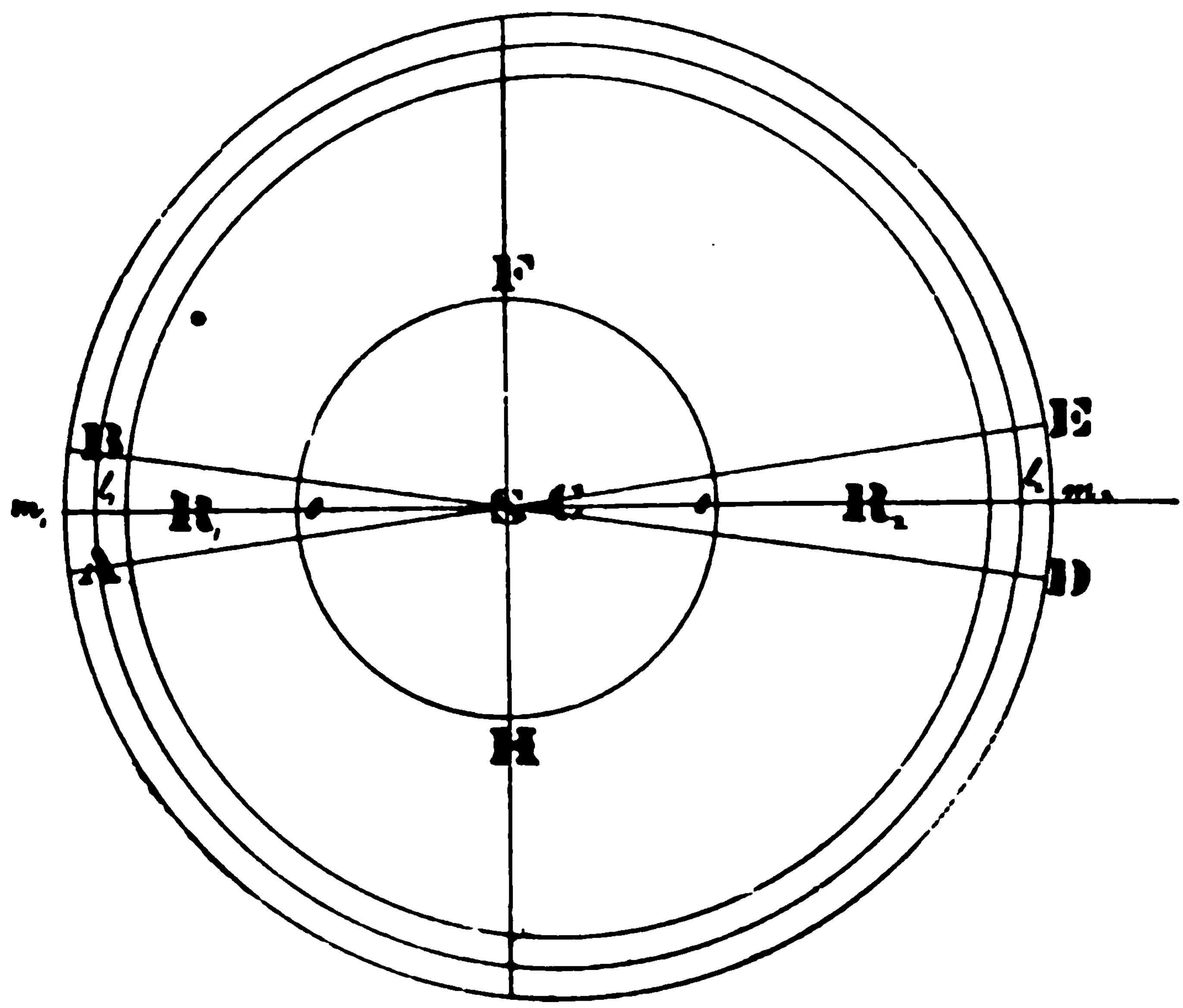

FIGURE 2.

The accelerative force between Saturn and the more distant segment towards the disturbing body is $F_2 = \frac{M + m^2}{R_2{}^2}$

Replacing m_1 and m_2 by their values, these forces become

$$F_1 = \frac{M}{R_1{}^2} + \vartheta\delta \cdot \frac{a_1}{R_1}$$

$$F_2 = \frac{M}{R_2{}^2} + \vartheta\delta \cdot \frac{a_2}{R_2}$$

The differences of these forces is

$$F_1 - F_2 = M . \left(\frac{1}{R_1^2} - \frac{1}{R_2^2}\right) + 9\delta . \left(\frac{a_1}{R_1} - \frac{a_2}{R_2}\right) \quad \text{(I)}$$

The density of the ring, δ, has been supposed to be the same in all its parts, and hence it is so in the two small segments. If, therefore, the cross-section of the ring has always the same area, it will be uniform and homogeneous; and whether solid or liquid, we may in such case replace a_2 by its equal a_1; and shall then have

$$F_1 - F_2 = M\left\{\frac{1}{R_1^2} - \frac{1}{R_2^2}\right\} + 9\delta a_1 . \left\{\frac{1}{R_1} - \frac{1}{R_2}\right\} \quad \text{(II)}$$

But since R_2 is greater than R_1, it follows that $\frac{1}{R_1}$ is greater than $\frac{1}{R_2}$, and hence $\frac{1}{R_1^2} > \frac{1}{R_2^2}$. The whole second member of (II) is therefore *positive*. Hence $F_1 > F_2$. The mutual attraction between the planet and the nearer segment surpasses that between the planet and the more distant segment. The same is true in this case for any pair of opposite segments included between any two planes through S, inclined in any manner to *FSH*. Hence, in this case of a uniform and homogeneous ring, the whole attraction between the planet and the nearer portion of the ring is greater than that between the planet and the remote portion. The consequence is that the nearer portion of the ring is continually drawn down towards the planet, with accelerated velocity, the center of the ring flying away from the planet, as if repelled by it.

This consequence, however, holds good only on the supposition that the ring is of uniform dimensions, and constant density, in all its parts. It is the case of La Place's homogeneous, uniform solid ring. But the conclusion holds good equally for a liquid or fluid ring, provided it is obliged to preserve the same area of cross-section, $a_1 = a_2$, as well as the same density.

But the ring is revolving around Saturn, and its centre must be carried around him also with a velocity that produces a centrifugal force applied to this centre. This centrifugal force, combined with the repulsive force with which the centre of the uniform ring is driven away from that of

Saturn, must produce a motion, as La Place points out, convex to the centre of Saturn. The orbital motion of the ring, under these circumstances, only helps the more swiftly to drive away its centre from that of the planet, and to precipitate the ring upon the planet with a more violent collision.

Thus the unstable equilibrium of any uniform, homogeneous ring revolving about any planet is demonstrated, if it be subject to the external attraction of any other body.

Professor Peirce's idea was, that the several satellites of Saturn, some of them revolving rapidly around him, might, by their different attractions in different and continually changing directions, help to bring back the ring's centre to that of the planet, and thus restore the equilibrium to stability. But suppose the eight satellites, at a certain moment of time, to have any given arrangement around Saturn. They would then constitute eight given disturbing forces, of different intensities, in eight given directions. There would necessarily be a certain resultant of these eight forces in a certain direction Unless this resultant were always zero, with every possible arrangement or configuration of the satellites, the resultant disturbing force, in some particular direction, would remove the ring's centre away from that of Saturn, in the direction of that resultant Long before the direction and amount of that resultant could be reversed, in order to destroy its effect, the centre of the ring will have gone so far from that of the planet, that the inverse square of the distances, together with the great mass of Saturn, would forbid the possibility of repairing the mischief of the disturbing force. A uniform, homogeneous ring, whether solid or fluid, cannot therefore continue to revolve around a planet, with stable equilibrium, in the presence of external disturbing forces.

But we have seen that if the ring be liquid, or fluid, the action of each satellite, or other disturbing body, while it tends to draw away the ring's centre from Saturn toward the disturbing body, tends at the same time to produce in the ring opposite tidal elevations in the line of its action. Moreover, the tidal elevation, on the side of the ring nearest the disturbing body, exceeds that in the remotest part of the ring, *exactly in the same ratio as the two disturbing forces,*

which by their difference tend to withdraw the ring's centre from that of the planet.

The consequence of this state of things is, that when the centre of the ring, C, moves toward the disturbing satellite, and away from Saturn's centre, the superior tidal effect at m_2, nearest the satellite, above that farthest from the satellite, at m_1, will cause the nearer cross-section, a_2, to be greater than the remote one, a_1. Therefore we have $a_2 > a_1$.

Hence, in equation (I), while R_1 and R_2 are still nearly equal, it is possible to have $\frac{a_2}{R_2}$ greater than $\frac{a_1}{R_1}$, so that the second term, $\vartheta\delta\left\{\frac{a_1}{R_1}-\frac{a_2}{R_2}\right\}$, shall be *negative*.

If this negative term be then equal to, or a little greater than, the small positive term $M\left\{\frac{1}{R_1^2}-\frac{1}{R_2^2}\right\}$ as may well be the case when R_2 is very nearly equal to R_1, the effect will be to make $F_1 = F_2$, or $F_1 > F_2$. In this case the centre, C, will be brought back towards the planet's centre and the equilibrium will become stable.

Let us see what will be requisite in order to make $F_1 = F_2$ or $F_1 - F_2 = 0$.

In this case equation (I) will become

$$\mathrm{M}\left\{\frac{1}{\mathrm{R}_1{}^2}-\frac{1}{\mathrm{R}_2{}^2}\right\}+\vartheta\delta\left\{\frac{a_1}{\mathrm{R}_1}-\frac{a_2}{\mathrm{R}_2}\right\}=0.$$

$$\therefore \vartheta\delta\,\frac{a_2}{\mathrm{R}_2}=\vartheta\delta\,.\frac{a_1}{\mathrm{R}_1}+\mathrm{M}\left\{\frac{1}{\mathrm{R}_1{}^2}-\frac{1}{\mathrm{R}_2{}^2}\right\}$$

$$\therefore a_2=\frac{\mathrm{R}_2}{\mathrm{R}_1}\,.\,a_1+\frac{\mathrm{M}}{\vartheta\delta}\,.\left\{\frac{1}{\mathrm{R}_1}\,.\,\frac{\mathrm{R}_2}{\mathrm{R}_1}-\frac{1}{\mathrm{R}_2}\right\}. \qquad \text{(III.)}$$

It is evident from (III) that when R_2 and R_1 are still very nearly equal, so that $R_2 = R_1 + \Delta R$, ΔR being very small compared with R_1, it follows that

$$a_2=\left\{1+\frac{\Delta\mathrm{R}}{\mathrm{R}_1}\right\}.\,a_1+\frac{\mathrm{M}}{\vartheta\delta}\,.\left\{\frac{1}{\mathrm{R}_1}\left\{1+\frac{\Delta\mathrm{R}}{\mathrm{R}_1}\right\}-\frac{1}{\mathrm{R}_1+\Delta\mathrm{R}}\right\}$$

$$\therefore a_2 = a_1 + a_1\,.\,\frac{\Delta\mathrm{R}}{\mathrm{R}_1}+\frac{\mathrm{M}}{\vartheta\delta}\left\{\frac{1}{\mathrm{R}_1}+\frac{\Delta\mathrm{R}}{\mathrm{R}_1{}^2}-\frac{1}{\mathrm{R}_1}\left\{1+\frac{\Delta\mathrm{R}}{\mathrm{R}_1}\right\}^{-1}\right\}$$

Retaining only the first power of the small fraction $\frac{\Delta\mathrm{R}}{\mathrm{R}_1}$ it follows that

$$a_2 = a_1 + a_1 \cdot \frac{\Delta R}{R_1} + \frac{2M}{3\delta} \cdot \frac{\Delta R}{R_1^2}$$

It is thus evident that a very small increase of a_2 over a_1 is sufficient, when ΔR is very small in comparison with R_1, to make the force F_1 equal to F_2; and a very slight additional increase of a_2 over a_1 will make F_2 greater than F_1. This slight additional increase of a_2 over a_1, which the tidal action of each satellite seems abundantly able to provide in its action on a fluid ring, will tend to restore the centre of the ring to that of the planet, thus maintaining the equilibrium in a *stable condition.*

It is now evident that, not only each satellite, but the sun, or any planet, by the same reasoning, furnishes separately, and in just measure, the bane and antidote for destroying and restoring the stability of equilibrium of the rings of Saturn, *on the sole condition of their being fluid*, and therefore subject to a *tidal change of figure*. Perhaps also, the difference of action of the satellites on the outer and inner edge, and on the middle of the rings, may account for their temporary openings, and subsequent closing up, as observed by Mr. George P. Bond and others.

DOUBLE-STAR OBSERVATIONS AT THE WASHBURN OBSERVATORY.

GEORGE C. COMSTOCK.*

For The Messenger.

The double-star observations made with the 15½-inch equatorial of the Washburn Observatory during the years 1888-89 are now nearly ready for publication, but as some months must elapse before the volume containing them can be distributed, it has seemed proper to comply with the request of the editor of The Sidereal Messenger for astronomical news, and to present here some of the more interesting results of the observations of that series.

The stars observed are chiefly those discovered at the Washburn Observatory during the years 1881-4, and a principal purpose of the work has been to select from this list of

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more than 250 stars, those interesting on account of rapid relative motion or other peculiarity. The only observations available for comparison with my own are those made by Mr. Burnham in 1881, and the interval of time between his observations and mine being only seven years, it is evident that only large relative motions can be detected by a comparison of our results. It is well known that observers differ among themselves to a marked degree in the measurement of position angles and distances, *i. e.*, there is a *personal equation* which must be allowed for, before the observations of two different observers can properly be compared with each other. This *personal equation* between Mr. Burnham and myself, I have derived from a comparison of 135 double-stars which we have observed in common, and in deriving relative motion of the components of a double-star, I have in all cases reduced my measures to his standard by applying the *personal equation* thus determined.

The following list shows all of the cases in which a relative motion seems assured:

Ll. 4370; R. A. = 2ʰ 16ᵐ.8; Decl. = + 57°40′; Mags. 8–10.

1881.56	p = 186°.5	s = 1″.78	Observed 3 nights.
1888.11	186 .4	2 .31	" 3 "

β 794; R. A. = 11ʰ 47ᵐ.2; Decl. = + 74°26′; Mags. 7–8.

1881.34	p = 106°.6	s = 0″.42	Observed 5 nights.
1889.19	131 .2	0 .41	" 4 "

β 800; R. A. = 13ʰ 10ᵐ.8; Decl. = + 17°40′; Mags. 7–10.

1881.36	p = 121°.5	s = 1″.26	Observed 4 nights.
1888.39	120 .2	2 .22	" 3 "

β 815; R. A. = 16ʰ 23ᵐ.3; Decl. = + 43°11′; Mags. 8–10.

1881.30	p = 348°.4	s = 6″.39	Observed 3 nights.
1888.54	343 .3	7 .35	" 3 "

S. D. 14°; 4712; R. A. = 17ʰ 31ᵐ.7; Decl. = − 14°46′; Mags. 9–9.

1881.38	p = 338°.2	s = 1″.37	Observed 2 nights.
1888.60	333 .4	1 .74	" 3 "

β 838; R. A. = 21ʰ 14ᵐ.8; Decl. = + 2°37′; Mags. 8–9.

1881.66	p = 90°.3	s = 1″.28	Observed 3 nights.
1887.77	97 .1	1 .56	" 3 "

β 848; R. A. = 22ʰ 50ᵐ.0; Decl. = + 57°44′; Mags. 8–11.

1881.67	p = 5°.8	s = 2″.76	Observed 3 nights.
1888.40	2 .4	2 .36	" 2 "

D.M. 38°; 5112; R. A. = 23ʰ 55ᵐ.3; Decl. = + 38°58′; Mags. 8–9.

1881.71	p = 124°.1	s = 0″.62	Observed 3 nights.
1888.17	105 .5	0 .49	" 2 "

A triple star interesting by reason of the closeness of all of the components is:

S. D. 14°; 1171; R. A. $5^h 28^m.6$; Decl. = $-14°27'$

This was recognized as a double-star by Professor Holden in 1882 or 1883, the exact date I cannot find. The star was not measured, but the estimated position of the components was $p = 230°$ $s = 1''$, magnitudes 10–10. I measured the star twice in 1888 without noting anything peculiar except that the definition appeared worse than in the case of other neighboring stars, but subsequently I found a minute companion between the principal components. The positions are:

	Stars A and B.		
1888.55	$p = 219°.6$	$s = 2''.76$	Observed 4 nights
	Stars A and C.		
1888.91	$p = 252°.2$	$s = 1''.80$	Observed 2 nights

making this an unusually close triple star.

ON THE SPECTRUM OF ζ URSÆ MAJORIS.*

EDWARD C. PICKERING.

In the Third Annual Report of the Henry Draper Memorial, attention is called to the fact that the K line in the spectrum of ζ Ursæ Majoris occasionally appears double. The spectrum of this star has been photographed at the Harvard College Observatory on seventy nights and a careful study of the results has been made by Miss A. C. Maury, a niece of Dr. Draper. The K line is clearly seen to be double in the photographs taken on March 29, 1887, on May 17, 1889 and on August 27 and 28, 1889. On many other dates the line appeared hazy, as if the components were slightly separated, while at other times the line appears to be well defined and single. An examination of all the plates leads to the belief that the line is double at intervals of 52 days, beginning March 27, 1887, and that for several days before and after these dates it presents a hazy appearance. The doubling of the line was predicted for October 18, 1889, but only partially verified. The line appeared hazy or

* Read at the Philadelphia meeting of the Nat. Acad. of Sciences Nov. 13, 1889.

slightly widened on several plates but was not certainly doubled. The star was however low and only three prisms could be used, while the usual number was four. The predicted times at which the line should be again double are on December 9, 1889, and on January 30, 1890. The hydrogen lines of ζ Ursæ Majoris are so broad that it is difficult to decide whether they are also separated into two or not. They appear, however, to be broader when the K line is double than when it is single. The other lines in the spectrum are much fainter, and although well shown when the K line is clearly defined, are seen with difficulty when it is hazy. Several of them are certainly double when the K line is double. Measures of these plates gave a mean separation of 0.246 millionths of a millimeter for a line whose wave-length is 448.1 when the separation of the K line whose wave-length is 393.7, was 0.199. The only satisfactory explanation of this phenomenon as yet proposed is that the brighter component of this star is itself a double-star having components nearly equal in brightness and too close to have been separated as yet visually. Also that the time of revolution of the system is 104 days. When one component is approaching the earth all the lines in its spectrum will be moved toward the blue end, while all the lines in the spectrum of the other component will be moved by an equal amount in the opposite direction if their masses are equal. Each line will thus be separated into two. When the motion becomes perpendicular to the line of sight the spectral lines recover their true wave-length and become single. An idea of the actual dimensions of the system may be derived from the measures given above. The relative velocity as derived from the K line will be 0.199 divided by its wave-length 393.7 and multiplied by the velocity of light 186,000 which is equal to 94 miles a second. A similar calculation for the line whose wave-length is 448.1 gives 102 miles per second. Since the plates were probably not taken at the exact time of maximum velocity these values should be somewhat increased. We may, however, assume this velocity to be about one hundred miles per second. If the orbit is circular and its plane passes through the sun, the distance traveled by one component of the star regarding the other as fixed would be 900 million miles, and the distance

apart of the two components would be 143 million miles, or about that of Mars and the sun. The combined mass would be about forty times that of the sun to give the required period. In other words, if two stars each having a mass twenty times that of the sun revolved around each other at a distance equal to that of the sun and Mars, the observed phenomenon of the periodic doubling of the lines would occur. If the orbit was inclined to the line of sight its dimensions and the corresponding masses would be increased. An ellipticity of the orbit would be indicated by variations in the amount of the separation of the lines, which will be considered hereafter. The angular distance between the components is probably too small to be detected by direct observation. The greatest separation may be about 1.5 times the annual parallax Some other stars indicate a similar peculiarity of spectrum, but in no case is this as yet established.

Harvard College Observatory,
Cambridge, U. S., Nov. 12, 1889.

ADDENDA.—Dec. 17. The predicted doubling of the lines of ζ Ursæ Majoris on December 8th was confirmed on that day by each of three photographs. Two more stars have been found showing a similar periodicity: β Aurigæ and *b* Ophiuchi (H. P. 1100 and 2909).

Jan. 11, 1890. Later observations make it probable that the period of ζ Ursæ Majoris is 52 days instead of 104, and that its orbit is noticeably elliptical. The velocity of the components of β Aurigæ seems to be 150 miles per second, their period 4 days, their orbit nearly circular, with a radius of 8,000,000 miles, and their masses 0.1 or 0.2, that of the sun being unity.

Queries 1 What is the equation, in Cartesian co-ordinates, of an ellipse passing through five points x_1y_1, x_2y_2, x_3y_3, x_4y_4, x_5y_5, or the simplest way of forming it?

2 Given the elements of the orbit of a binary star, how should the orbital velocity in the line of sight vary (*a*) as the position angle varies (*b*) at each epoch during the period of the system? QUERIST

A complete answer to the first query will furnish the means of determining the orbit of a binary star from five observations The second branch of the second query is needed, for a star like Algol, where one can not observe the position-angle, and can only note the time of observations with the spectroscope

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury was quite conspicuous in the southwest for a few evenings in January. It has now passed inferior conjunction, and will be at greatest elongation west from the sun 26° 50′ on Feb. 23. It will then be farther south than the sun and hence in our latitude will rise only a little over an hour earlier than the sun.

The last number (2944) of the *Astronomische Nachrichten* contains a very important paper on "The Rotation of Mercury," by Professor G. V. Schiaparelli, of the Observatory at Milan, Italy. The paper being written in Italian, which we do not read readily, we cannot give the substance of the paper, but the important conclusions which we have been able to make out are, (1) that Mercury rotates upon its axis once in about 88 days; (2) that the axis of rotation is nearly perpendicular to the plane of the planet's orbit. These conclusions he draws from the discussion of a series of observations made in 1882 and 1883 with the 8-inch refractor (with which he discovered the "canals" of Mars) and verified by observations made in subsequent years with the same instrument and with the new 18-inch refractor. If this period of rotation is correct, Mercury always turns the same side toward the sun, just as the moon always turns the same side to the earth. Professor Schiaparelli finds that, as in the case of the moon, there is a libration in longitude which, owing to the large eccentricity of Mercury's orbit, amounts to about 47°. He gives a map of the dark markings upon the visible surface of the planet, which are so similar to the markings upon his map of Mars as to suggest that possibly Professor Schiaparelli may have a bias for seeing that particular kind of markings.

Venus changes during February from "morning" to "evening star" passing through superior conjunction Feb. 18. During this month she will be too near the rays of the sun to be easily seen.

Mars rises soon after midnight and will soon be in good position for observation in the southern hemisphere. He is too far south in declination for good observations in this latitude. The diameter of his disk on March 1 will be 4.7″ and 0.898 of the illuminated surface will be visible from the earth. Mars passes, this month, through Libra into Scorpio. On March 4 at 10 P. M., central time, he will be within 8′ of the bright star β Scorpii; so close as to be within the same field of view in large telescopes.

Jupiter becomes "morning star" in place of Venus, rising from an hour to two hours earlier than the sun. He may be found near the southeast point of the horizon in this latitude. The last number of the *Monthly Notices* contains reports of the occultation of Jupiter on Aug. 7 last, observed by three observers at the Radcliffe Observatory, and by Captain William Noble at Forest Lodge, Maresfield. Six engravings accompany the reports, showing the shadow on Jupiter's disk parallel to the edge of the moon as seen by three of the observers, two of them noticing it both at immersion and emersion, and while Jupiter was at a short distance from the edge of the moon as well as when in contact with it.

Saturn is now in good position for observation in the evening. He may be easily recognized in the east near the first magnitude star Regulus in the group of the Sickle. The last November number of the *Monthly Notices* contains excellent ephemerides of Saturn's satellites for the first half of this year, by Mr. Marth. The earth is approaching so near to the plane of Saturn's rings and of the satellite orbits that some of the satellites will suffer occultation by the planet and the rings. There may be also eclipses of the satellites in the shadow of the planet. Mr. Marth has indicated the times of such phenomena as closely as the elements of the satellites' orbits will permit. Iapetus will be in transit across the ball of the planet March 2 from 3.4 A. M. to 8.8 A. M. central time entering upon the disk 8″ south and leaving it 6″ south of the center. Mr. Marth says: "As the latitudes of the inner satellites above the plane of the planet's equator, and also the true extent of the shadow-cone, are not known, it is uncertain when the cycles of the eclipses of the several satellites begin. In the case of *Tethys* the first eclipses are not observable from the earth, since they take place while the satellite is hidden by the planet. But in the case of *Dione* the satellite remains outside the planet's disc, and it will be worth while to watch it about the times of the heliocentric conjunctions given in the list, and to observe some of the earlier eclipses, taking care that the times of the observed disappearance and reappearance should refer to similar phases. Observers with powerful telescopes should look out whether, at the predicted time of "Te. n." [Tethys north of planet] in February and March, the shadow of *Tethys* can be discerned on the planet's disc. The conjunctions of *Dione* and *Rhea* with the center of the planet are, during the present apparition of *Saturn*, most favorable for the determination of the orbital longitudes of these satellites, and it would be a pity if the opportunities for observing them were neglected. By timely publication or communication of their observations of such conjunctions and of conjunctions of *Mimas*, *Enceladus*, and *Tethys* with the ends of the ring, observers would have the satisfaction of rendering their contributions available for the proper prediction of the occurrences which will make the observations of the satellites during the next apparitions of *Saturn* specially interesting."

Uranus may be observed after midnight. He is in Virgo about half way between Spica and the fourth magnitude star Kappa.

Neptune will be at quadrature with the sun Feb. 19, crossing the meridian then at 6 P. M. He is in Taurus about half way on a line between Aldebaran and the Pleiades.

MERCURY.

1890	R. A. h m	Decl. ° ′	Rises h m	Transits. h m	Sets h m
Feb. 24......	20 47.0	−18 08	5 40 A. M.	10 28.9 A. M.	3 18 P. M.
Mar. 6......	21 36.9	−15 50	5 40 "	10 39.4 A. M.	3 38 "
16......	22 34.7	−11 21	5 40 "	10 57.8 "	4 16 "

VENUS.

Feb. 24......	22 39.6	−10 01	6 58 A. M.	12 21.3 P. M.	5 45 P. M.
Mar. 6......	23 26.1	− 5 12	6 45 "	12 28.3 "	6 11 "
16......	0 11.8	− 0 09	6 32 "	12 34.5 "	6 37 "

MARS.

Feb. 24......	15 43.9	−18 31	12 40 A. M.	5 26.7 A. M.	10 14 A. M.
Mar. 6......	16 01.2	−19 30	12 22 "	5 04.6 "	9 47 "
16......	16 16.7	−20 19	12 02 "	4 40.7 "	9 19 "

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
			JUPITER.		
Feb. 24	20 10.1	−20 23	5 14 A.M.	9 52.2 A.M.	2 30 P.M.
Mar. 6	20 18.7	−19 57	4 41 "	9 21.6 "	2 02 "
16	20 26.7	−19 31	4 08 "	8 50.3 "	1 33 "
			SATURN.		
Feb. 24	10 10.9	+13 05	4 54 P.M.	11 50.7 P.M.	6 47 A.M.
Mar. 6	10 07.9	+13 22	4 11 "	11 08.4 "	6 06 "
16	10 05.2	+13 37	3 28 "	10 26.3 "	5 25 "
			URANUS.		
Feb. 24	13 38.9	− 9 38	9 53 P.M.	3 18.1 A.M.	8 43 A.M.
Mar. 6	13 37.9	− 9 32	9 12 "	2 37.8 "	8 03 "
16	13 36.7	− 9 25	8 31 "	1 57.3 "	7 23 "
			NEPTUNE.		
Feb. 24	4 00.2	+18 56	10 19 A.M.	5 41.0 P.M.	1 04 A.M.
Mar. 6	4 00.6	+18 58	9 40 "	5 02.3 "	12 25 "
16	4 01.3	+19 00	9 01 "	4 23.5 "	11 47 P.M.
			THE SUN.		
Feb. 24	22 31.7	− 9 16	6 46 A.M.	12 13.4 P.M.	5 42 P.M.
Mar. 6	23 09.1	− 5 28	6 29 "	12 11.3 "	5 54 "
16	23 45.8	− 1 32	6 10 "	12 08.7 "	6 07 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
Mar. 6	ν Virginis	4	13 30	82	14 30	347	1 00
9	94 Virginis	6½	11 59	155	12 59	270	1 00

Minima of Variable Stars of the Algol Type.

	R. A.	Decl.	Range of Magnitude.	Period.	Approx. Central Times of Minima.
	h m s	° ′		h m s	
U Cephei	0 52 32	+ 81 17	7.1 to 9.2	2 11 50	Feb. 18, 12ʰ mdn. 23, 12ʰ mid.; 28, 12ʰ mid.; Mar. 5, 11ʰ P.M.; 10, 11ʰ P.M.; 15, 11ʰ P.M.
Algol	3 01 01	+ 40 32	2.3 to 3.5	2 20 49	Feb. 27, 3ʰ A.M.; Mar. 2, 12ʰ mid.; 4, 9ʰ P.M.; 7, 6ʰ P.M.
λ Tauri	3 54 35	+ 12 11	3.4 to 4.2	3 22 52	Mar. 7, 11ʰ P.M.; 11, 10ʰ P.M.; 15, 9ʰ P.M.
R Canis Maj.	7 14 30	− 16 11	5.9 to 6.7	1 03 16	Feb. 17, 7ʰ P.M.; 18, 10ʰ P.M.; 20, 1ʰ A.M.; 26, 9ʰ P.M.; 27, 12ʰ mid.; Mar. 1, 4ʰ A.M.; 6, 8ʰ P.M.; 7, 11ʰ P.M.
S Cancri	8 37 39	+ 19 26	8.2 to 9.8	9 11 38	Feb. 15, 11ʰ P.M.; Mar. 6, 11ʰ P.M.
δ Libræ	14 55 06	− 8 05	5.2 to 6.2	2 07 51	Feb. 16, 12ʰ mid., 24, 2ʰ A.M.;
U Coronæ	15 13 43	+ 32 03	7.5 to 8.9	3 10 51	Feb. 18, 11ʰ P.M.; 25, 9ʰ P.M.; Mar. 15, 4ʰ A.M.
U Ophiuchi	17 10 56	+ 1 20	6.0 to 6.7	0 20 08	Feb. 16, 2 A.M.

Phases of the Moon.

				Central Time.	
			d	h m	
New Moon	1890	Feb.	19	4 28	A. M.
First Quarter	"	"	26	8 06	A. M.
Full Moon	"	Mar.	6	12 47	P. M.
Last Quarter	"	"	13	10 05	P. M.
Perigee	"	Feb.	17	7 42	P. M.
Apogee	"	Mar.	1	9 42	P. M.

Ephemerides of Saturn's Satellites.

[Computed by A. Marth, Monthly Notices R. A. S., vol. L, No. 1, p. 56.]

Feb. 15	11.2 a. m.	Te. n.
	8.5 p. m.	Rh. w.
	8.6 p. m.	Mi. s.
16	3.0 a. m.	En. s.
	9.9 a. m.	Te. s.
	11.7 a. m.	Di. s.
	7.2 p. m.	Mi. s.
	7.4 p. m.	En. n.
	11.6 p. m.	Rh. s.
17	1.8 a. m.	* 8 m. precedes 12.7s. on parallel.
	8.5 a. m.	Te. n.
	5.8 p. m.	Mi. s.
	7.0 p. m.	* 8 m s. 78"
	8.5 p. m.	Di. n.
18	2.7 a. m.	Rh. e.
	7.2 a. m.	Te. s.
	4.4 p. m.	Mi. s.
	8.8 p. m.	En. s.
19	5.3 a. m.	Di. s.
	5.7 a. m.	Rh. n.
	5.8 a. m.	Te. n.
	1.2 p. m.	En. n.
	3.0 p. m.	Mi. s.
20	4.5 a. m.	Te. s.
	5.6 a. m	Tit. n. 34"
	8.8 a. m.	Rh. w.
	1.6 p. m.	Mi. s.
	2.2 p. m.	Di. n.
	10.1 p. m.	En. n.
21	3.1 a. m.	Te. n
	11.9 a. m.	Rh. s.
	2.5 p. m.	En. s.
	11.0 p. m.	Di. s.
	11.5 p. m.	Mi. n.
22	1.7 a. m.	Te. s.
	3.0 p. m.	Rh. e
	10.2 p. m.	Mi. n.
	11.4 p. m.	En s.
23	12.4 a. m.	Te n.
	7.8 a. m.	Di. n.
	3.8 p m.	En. n.
	6.1 p m.	Rh. n
	8.8 p m.	Mi. n.
	11.0 p. m.	Te. s.
24	4.6 p. m.	Di. s.
	7 4 p. m	Mi. n

Feb. 24	9.1 p. m.	Rh. w.
	9.7 p. m.	Te. n.
25	12.7 a. m.	En. n.
	5.1 p. m.	En. s.
	6.0 p. m.	Mi. n.
	8.3 p. m.	Te. s.
26	12.2 a. m.	Rh. s.
	1.5 a. m.	Di. n.
	4.6 p. m.	Mi. n.
	7.0 p. m.	Te. n.
27	2.0 a. m.	En. s.
	3.3 a. m.	Rh. e.
	10.3 a. m.	Di. s.
	3.2 p. m.	Mi. n.
	5.6 p. m.	Te. s.
	6.4 p. m.	En. n.
28	6.4 a. m.	Rh. n.
	10.4 a. m.	Tit. s. 36"
	1.8 p. m.	Mi. n.
	4.3 p. m.	Te. n.
	7.1 p. m.	Di. n.
Mar. 1	1.2 a. m.	Mi. s.
	2.8 a. m.	Tit. c. Jap. 19"
	9.5 a. m.	Rh. w.
	2.9 p. m.	Te. s.
	6.3 p. m.	Te. c. Jap. 3"
	7.8 p. m.	En. s.
	11.8 p. m.	Mi. s
2	3.4 a. m.	Jap. Transit Ingress 8" s.
	3.9 a. m.	Di. s.
	8.8 a. m.	Jap. Transit Egress 6" s.
	12.5 p. m.	Rh. s.
	1.6 p. m.	Te. n.
	4.6 p. m.	Jap. c. prec. end of ring 4" s.
	6.6 p. m.	Mi. c. Jap. 1"
	7.4 p. m.	Mi. c. prec. end of ring 4"
	10.9 p. m.	En. c. Jap. 1"
3	1.5 a. m.	En. c. prec. end of ring 6"

Mar. 3	3.8 a. m.	Te. c. Jap. 3"
	12.2 p. m.	Te. s.
	12.8 p. m.	Di. n.
	3.6 p. m.	Rh. e.
4	10.8 a. m.	Te. n.
	6.7 p. m.	Rh. n.
	9.6 p. m.	Di. s.
5	9.5 a. m.	Te. s.
	9.8 p. m.	Rh. w.
6	6.4 a. m.	Di. n.
	8.1 a. m.	Te. n.
7	12.9 a. m.	Rh. s.
	6.8 a. m.	Te. s.
	3.3 p. m.	Di. s.
8	3.1 a m.	Tit. n. 38"
	4.0 a. m.	Rh. e.
	5.4 a. m.	Te. n.
	4.2 p. m.	En. s.
9	12.1 a. m.	Di. n.
	4.1 a. m.	Te. s.
	7.0 a. m.	Rh. n.
	12.0 mdn.	Mi. n.
10	1.0 a. m.	En. s.
	2.7 a. m.	Te. n.
	8.9 a. m.	Di. s.
	10.1 a. m.	Rh. w.
	5.5 p. m.	En. n.
	10.6 p. m.	Mi. n.
11	1.4 a. m.	Te. s.
	1.2 p. m.	Rh. s.
	5.7 p. m.	Di. n.
	9.2 p. m.	Mi. n.
	12.0 mdn.	Te. n
12	4.3 p. m.	Rh. e.
	6.8 p. m.	En. s.
	7.8 p. m.	Mi. n.
	10.7 p. m.	Te. s.
13	2.6 a. m.	Di. s.
	11.2 a. m.	En. n.
	6.5 p. m.	Mi. n.
	7.4 p. m.	Rh. n.
	9.3 p. m.	Te n.
14	11.4 a. m.	Di. n.
	5.1 p. m.	Mi. n.
	8.0 p. m.	Te. s.
	8.1 p. m.	En. n.
	10.5 p. m.	Rh. w.

En = Enceladus; Di. = Dione; Jap. = Japetus; Mi. = Mimas; Rh. = Rhea; Te = Tethys; Tit. = Titan; c. = conjunction; e. = eastern elongation; w. = western elongation; n. = north of center of planet; s. = south of center of planet. The conjunctions of the three innermost planets with the ends of the ring take place in the case of Mimas abou 3.0h, Enceladus, 3.2h, Tethys, 3.5h before and after the predicted conjunctions with the center, which are not observable.

Milton Updegraff, of Cordoba Observatory, Argentine Confederation, South America, in a recent letter, says: "Auwers' list of 480 fundamental stars (for southern zone observations), which I have been working at during the past two years, will be finished within a month or two, and soon after its completion I expect to return to the United States."

COMETS.

Comet 1881 V (Denning). The following ephemeris, from *Astronomische Nachrichten*, No. 2942, p. 222, was computed by Dr. B. Matthiesen, taking account approximately of the perturbations by Jupiter, which in 1887 were very considerable and uncertain in amount. Perihelion passage falls on May 9, but under such unfavorable circumstances that the theoretical brightness of the comet will then be less than one-third its brightness at the time of discovery in 1881, and only a little brighter than when it was last observed in that year. It will be a morning comet, rising at best only an hour and a half earlier than the sun, so that it is extremely doubtful whether it will be detected at this apparition.

1890	α app.	δ app.	log r	log Δ	L.
Feb. 10	$19^h\ 46^m\ 14^s$	$-23°\ 40.4'$	0.2008	0.3782	0.07
14	19 59 19	−23 13.0			
18	20 12 50	−22 40.5	0.1735	0.3546	0.09
22	20 26 49	−22 02.4			
26	20 41 16	−21 18.2	0.1440	0.3305	0.11
Mar. 2	20 56 13	−20 27.6			
6	21 11 40	−19 29.9	0.1122	0.3063	0.15
10	21 27 35	−18 24.6			
14	21 44 01	−17 11.4	0.0782	0.2830	0.19
18	22 10 59	−15 49.8			
22	22 18 27	−14 19.6	0.0420	0.2615	0.25
26	22 36 25	−12 40.6			
30	22 54 52	−10 53.0	0.0040	0.2430	0.32

Comet 1884 II (Barnard's). Since writing the note on this comet last month the *Astronomische Nachrichten*, Nos. 2938–39, have come to hand, containing a definitive determination of the elements by Dr. A. Berberich:

Epoch 1884, Aug. 16.5 Berlin mean time.

$$\begin{aligned}
M &= 359°\ 59'\ 49''.13 + \ \ 2.50\,du \\
\omega &= 301\ \ 01\ \ 58\ .63 - 21.10\,du \\
\Omega &= \ \ \ 5\ \ 08\ \ 59\ .12 + 26.44\,du \\
i &= \ \ \ 5\ \ 27\ \ 38\ .40 - \ \ 5.53\,du \\
\varphi &= \ \ 35\ \ 44\ \ 50\ .92 - 98.25\,du \\
\mu &= 657''.0839 \pm 0''.8876
\end{aligned}
\quad \left.\begin{matrix}\omega\\ \Omega\\ i\end{matrix}\right\}\text{ Mean equinox 1884.0}$$

$\log a = 0.4882572 \qquad a = 3.07791$

Time of perihelion = 1884 Aug. 16.516543

Period = 1972.35 ± 2.66 days.

This period would have brought the comet to perihelion Jan. 9.87, 1890, but under such unfavorable conditions as to make it impossible to be seen. Since the longitude of the comet at perihelion was 306°, and that of the sun on Jan. 9, 290°, the comet was only 9° east from the sun, and it will remain near the sun for several months. In 1895 it will appear early in May, when the conditions for its re-discovery will be somewhat more favorable.

Comet 1888 III. Elements of the orbit of this comet have been computed by Lieut. Gen. J. T. Tennant (*Monthly Notices*, Nov. 1889, p. 43) from eight normal places, depending upon 179 observations extending from Aug. 9 to Oct. 27. "It would appear that the orbit is really elliptic,

though the eccentricity is very uncertain. Had the comet been discovered a few days sooner and observed about perihelion, we might have had doubts removed."

$$
\begin{aligned}
T &= \text{July } 31.0952 \\
\Omega &= 101^\circ\ 30'\ 11'' \\
\pi &= 160\ \ 38\ \ 50 \\
i &= 74\ \ 12\ \ 23 \\
\log q &= 9.9550614 \qquad q = 0.901704 \\
\varepsilon &= 0.9979
\end{aligned}
$$

Comet 1889 II. Professor E. Millesovich has computed elements of this comet from the observations of date March 31, April 29, August 29, and October 23, which represent an observation made at Vienna Nov. 21, within the corrections —0.9ˢ and —13″ (*Astr. Nach.* 2941).

$$
\begin{aligned}
T &= 1889 \text{ June } 10.80670 \text{ Berlin mean time.} \\
\left.\begin{aligned}\pi &= 186^\circ\ 46'\ 58.4'' \\ \Omega &= 310\ \ 42\ \ 09.7 \\ i &= 163.\ \ 50\ \ 26.0\end{aligned}\right\} &\ 1889.0 \\
\log q &= 0.353260;\ q = 2.25559.
\end{aligned}
$$

Comet 1889 VI (Swift, Nov. 17). The orbit of this comet proves to be elliptic and of short period. The elements derived are as yet somewhat uncertain, owing to the very slow motion of the comet. Of the two sets of elements given below, the first, by Rev. George M. Searle, depends upon three observations of dates Nov. 18, 26, and Dec. 13 (*Astr. Jour.* No. 208), the second, by Dr. K. Zelbr (*Astr. Nach.* No. 2944) upon three observations of dates Nov. 19, 29, and Dec. 9. The ephemerides at hand do not extend beyond Jan. 28.

Computer:	Rev. George M. Searle.		Dr. K. Zelbr.	
$T =$	1889 Nov. 29.8212 Gr. M. T.		1889 Nov. 29.66411 Ber. M. T.	
$\pi =$	40° 26′ 03″	1889.0	40° 55′ 52.8″	1889.0
$\omega =$	70 01 05	1889.0	69 29 12.7	1889.0
$\Omega =$	330 24 58	1889.0	331 26 40.1	1889.0
$i =$	10 15 03	1889.0	10 03 21.1	1889.0
$\log q =$	0.31746	$q = 1.3544$		
$\varphi =$	43° 03′ 18″		39 08 23.1	
$\log a =$	0.630275		0.559784	$a = 3.6290$
Period =	8.82 years.		6.91 years.	

Comet 1890 (Borrelly 1889 Dec. 12). Mr. G. A. Hill sends the following preliminary elements of this comet, depending upon observations only ten days apart. They do not differ very much from those of other computers so far as received.

$$
\begin{aligned}
T &= 1890 \text{ Jan. } 26.832 \\
\left.\begin{aligned}\pi &= 209^\circ\ 38'\ 49'' \\ \omega &= 197\ \ 22\ \ 35 \\ \Omega &= 12\ \ 16\ \ 14 \\ i &= 57\ \ 35\ \ 44\end{aligned}\right\} &\ 1890.0 \\
\log q &= 9.437828 \qquad q = 0.2745
\end{aligned}
$$

It is passing south rapidly, so that it will no longer be visible in this latitude. We have no ephemeris extending beyond Jan. 31. H. C. W.

Orbit of Comet g 1889 (Borrelly, Dec. 12). From my own observations of Dec. 17, 21, and 23, I have computed the following elements of Borrelly's new comet referred to apparent equinox:

$$\begin{aligned} T &= 1890, \text{Jan. } 24.9162 \text{ Gr. M. T.} \\ \pi &= 207^\circ\ 5'\ 13'' \\ \Omega &= 5\ \ 24\ \ \ 9 \\ i &= 55\ \ 59\ \ 44 \\ \log q &= 9.41694 \qquad q = 0.26118 \end{aligned}$$

O. C. WENDELL.

Harvard College Observatory, 1890, Jan. 6.

NEWS AND NOTES.

There are only the names of a few persons on our subscription lists from whom we have not received orders concerning renewals for 1890. We pre sume that such do not wish THE MESSENGER continued.

This number contains an unusual amount of mathematical matter, but we esteem it useful to the general reader as well as to the scholar. The habit should be formed of trying to read or do things that are mentally hard to do. Suppose one cannot fully and readily understand every point that a scholarly writer makes, that is no good reason why he should not try patiently to get something from such sources. The better way is to compel the mind to go deeper and higher every day by painstaking work.

We have not yet met with the degree of success in our illustrations which we hoped for four months ago, though very earnest efforts have been put forth constantly in this direction, with some gain, and promise of more in the future.

Two or three subscribers are inquiring concerning the purchase of smal second hand telescopes. Any persons having such instruments for sale, in good condition, are requested to give us full information.

An interested European subscriber and correspondent to THE MESSENGER has recently made some very pertinent suggestions in regard to mathematical articles. He says: "I wish some more good mathematicians would apply themselves to astronomical problems. Now, that the satellite theory of Algol seems to be proved, the variations of its period become important, as well as the much greater variations of a star of the same class in Cygnus. It would be easy to name other problems which it would be of much use to solve."

Professor H. A. Peck of the Observatory of Syracuse University, Syracuse, N. Y., has just completed a set of tables for the prediction of occultations for latitude + 43° 3′.

George A. Hill, Naval Observatory, Washington, D. C., has recently furnished THE MESSENGER very helpful suggestions and useful comet notes.

The Halsted Observatory of the College of New Jersey, Professor C. A. Young, Director, has just been fitted with a new electrical plant for managing the dome. A four horse power C. & C. motor is connected with the old machinery formerly driven by a four horse power Otto gas engine, and a Julien Storage battery of thirty-two cells supplies the current to work the motor. With this arrangement the observer himself can easily manage the apparatus alone. Formerly it was necessary to call on a machinist to start the engine, which was often a difficult operation, requiring a great expenditure of muscular energy, and a perfect knowledge of all the tricks and whims of the machine. When the engine was once started it was usually left to run during the whole time of observation, which, of course, involved a great waste of power, and was objectionable on account of the tremor noise and heat. The battery is charged at odd times as it becomes necessary either by a small dynamo (in the Observatory) which is driven by the gas engine, or by a current sent down from the dynamo house at the School of Science building, 1000 feet away.

Astronomy in the year 1886. The account of the progress of Astronomy in the year 1886 was prepared by William C. Winlock for the Smithsonian report for the years 1886-87, but the publication of the same was delayed until late last year, on account of the lack of appropriations for this class of work, if we are rightly informed. This makes the appearance and notice of this useful pamphlet late for our readers but we suppose it can not be helped in this instance on the part of those in the charge of its preparation. It is to be hoped that these reports subsequently will appear more promptly for the good of the science they are intended to serve.

The method and arrangement for the Review of Astronomy for 1886 is essentially the same as the companion numbers from 1879 to 1884, the object being to prepare a series of notes from all the various branches of Astronomy, that may be of service to those who have not access to a large astronomical library. The feature of astronomical bibliography is deservedly made prominent for that is certainly useful to the professional astronomer as a reference list of technical papers.

The article on the comets for the year is a suggestive one in regard to complete and ready reference by systematic designation. A grouping of the different names that individual comets take, as a side head, in different type is an excellent idea. Some such way of referring to comets after the year of their appearance has passed, would always be definite, avoid errors and save confusion. This series of astronomical notes is very well prepared as in fact, everything of the kind is that Mr. Winlock undertakes.

Quartz Fibre. This beautiful invention of Mr. Boys supplies exactly what is wanted for micrometer wires, or, in fact wherever a strong, regular and delicate thread is wanted. Almost anyone with a little patience and practice can make it, and the making is a very interesting experiment, well worth the doing of itself. These little threads can be had of any size, one ten thousandth of an inch diameter (if one cares to handle them as small), are perfectly round, straight and polished, which can be said of no other wire. A position micrometer recently fitted with wires of this material performs admirably.

C. C. HUTCHINS.

BOWDOIN COLLEGE, Jan. 1, 1890.

Delta and Mu Centauri Show F Hydrogen Line Bright. An examination by Mrs. M. Fleming of the photographs taken by Mr. Bailey in Peru has led to the discovery that the F line due to hydrogen is bright in δ and μ Centauri. Additional photographs with shorter exposure will be required to decide whether the other hydrogen lines are also bright since the spectra so far obtained are too intense. This makes the total number of objects of this class as yet discovered seven, γ Cassiopeiæ, φ Persei, π Aquarii, P Cygni, 28 Tauri (Pleione), δ Centauri and μ Centauri. The stars having bright lines in their spectra discovered by Rayet and the variable stars of long period belong to different classes.

New Artificial Horizon Apparatus. In the New York *Evening Post* of Dec. 18, 1889, the reviewer of "Hints to Travelers," a manual for explorers, published by the Royal Geographical Society of London, calls attention to the fact that the glass shades ordinarily used in connection with the artificial horizon in sextant work, may be dispensed with, a light wooden frame-work covered with gauze being substituted therefor.

Apropos of this subject it may be interesting to call attention to a comparatively new form of artificial horizon, which, as regards portability and ease of handling, presents marked advantage over the mercurial horizon. This new device consists of two dishes of glass, mounted with a space between them in a light brass frame which is supported by three leveling screws. The image of the object observed upon is, of course, reflected from the plane surface of the upper dish. The space between the dishes is nearly filled with ether, leaving a bubble which, by means of the leveling screws, enables the reflecting surface to be placed perpendicular to the direction of gravity. Sextant observers will do well to give this new horizon apparatus a trial.

JOHN TATLOCK, JR.

Bibliographie Generale de l'Astronomie, by J. C. Houzeau, Director of the Royal Observatory at Brussels and E. A. Lancaster, Librarian, is a work of very great labor and value. The second volume, containing 2225 pages, was published in 1882, and presents the following leading topics in separate sections: History and Study of Astronomy; Biographies of Astronomers; Spherical Astronomy; Theoretical Astronomy; Celestial Mechanics; Physical Astronomy; Practical Astronomy; Monographs on the Principal Bodies of the Solar System; and Stellar Astronomy. Each topic is arranged on some plan that makes reference to any matter belonging to it very easy and natural, the different kinds of type on the same page serving as an index. The amount of useful information collected in this volume is an agreeable surprise. The first part of the first volume by the same authors, and published by F. Hayez, printer for the Royal Academy of Belgium, appeared in 1887 and is a neat volume of 858 pages. The entire volume is devoted to printed works and manuscripts on astronomical themes. The first half of this part presents a series of articles on the intellectual development of different phases of the science of astronomy. The remaining topics for this part are two, viz: (1) Historical Works, (2) Astrology, with subjects in chronological order. Some idea of the generality and completeness of research will be conveyed to the reader, if we

say that under these two heads are found 3915 subjects each having a few points of interest for further guidance in study. The second part of this first volume was published in October last and was received only a few weeks ago. Its frontispiece is a beautiful plate engraving of J. C. Houzeau, and the introductory article is a biographical sketch of this distinguished and scholarly astronomer. The body of this part is divided into four sections treating of (1) Particular Biographies, (2) Didactic and General Works on Astronomy; (3) Spherical Astronomy, (4) Theoretical Astronomy. This work, as a whole, is a most useful part of an astronomical library, and will be welcomed by American astronomers especially those who read the French.

Photographic Notes. Reports from the eclipse expeditions are as yet meagre. The United States government expedition made large preparations for its photographic work, Mr. Carbutt and Mr. Wright being the photographers of the party. Professor Holden writes of their outfit: "They are provided with a photoheliograph, giving an image of the sun four inches in diameter. With this the partial phases will be photographed on orthochromatic plates (No. 16) and the total phase on orthochromatic plates (No. 27). A large mirror belonging to Professor Langley, an equatorial belonging to Harvard College Observatory, and twenty cameras are also provided for photography." Of the results we hear that all instruments worked perfectly, seventy photographs were secured before totality; clouds interfered with the work during the period of totality; after totality a number of pictures were secured. Twenty two-inch plates were used, upon each of these ten exposures could be made. Some of this party worked far out at sea on the steamer Pensacola, while others were on the Africn mainland near the mouth of the Congo.

The *Monthly Notices* of the Royal Astronomical Society for November makes the following statement in regard to the English eclipse expedition: "The objects of the photographic outfit of the eclipse expedition of the Royal Astronomical Society are threefold:

1. To detect any possible changes in the corona during the two hours and a half that elapse between totality at the respective stations.

2. To photograph the coronal extension as far as possible.

3. To determine the photometric intensity of the corona."

A diagram giving the mean daily area of sun spots for each degree of solar latitude has been prepared from photographs of the sun at the Royal Observatory, Greenwich, for the years 1874-1888. "The diagram shows in a marked manner the gradual decline in the distance from the equator of sun spots as the minimum is approached, and the sudden appearance of spots in high latitudes after the minimum is passed and a new cycle commenced."

Continued experiment with eikonogen is proving its exceptional value as a developer. J. B. Brown of the U. S. Army makes the following statements as the result of "assiduous experimenting." "I give the combination I am now using, and which gives by far the best general results.

No. 1—Sulphite soda, 240 grains, water pure, 16 ounces; dissolve and filter, then add eikonogen, 120 grains.

No. 2—Carbonate of potash, 20 ounces (Troy), water, 12 fluid ounces. Use three ounces of No. 1 with one part No. 2.

The result will be a clear, unstained negative, with every detail in shadows and lights clearly brought out, and the exposure may be less than one half that proper for a hydrochinon developer."

C. H. Poor, after experimenting on one hundred negatives of the same landscape, writes: "The conclusion I have come to is, that for shutter work eikonogen is without a peer; but for time exposures more snap and more contrast can be got from either pyro or hydro, with the advantage largely in favor of the latter."

The Solar Corona is the name of a recent paper prepared by Professor Frank H. Bigelow, and published by the Smithsonian Institution at Washington, D. C. The mode of attacking the puzzling problem of the corona is by the principles of spherical harmonics, and the author makes an interesting study of three points in the structure of the corona, viz.: (1) Polar rays nearly vertical to the coronal poles or axis of reference for the symmetrical figure, but inclining more from this axis than a radius vector to any point, as the vectoral angle increases; (2) Four wings disposed upon two axes, each inclined at an angle of 40° from the vertical; and (3) Extensive equatorial wings seen more distinctly at periods of solar quiescence. The supposition that supports the theory advanced is, that the rays observed are lines of force discharging coronal matter from the body of the sun, and that the phenomenon seen is similar to that of free electricity. The mathematical part of the paper presents both the harmonic theory and the geometrical. The former is drawn from well known treatises on harmonics by Todhunter, Thompson and Tait and others; but the more important feature is the application of this theory to the explanation of the corona. The author thinks that the straight polar rays of high tension carry the lightest substances, as hydrogen, meteoric matter, *debris* of comets, and other coronal material, away from the sun, and they become soon invisible by dispersion; that the strong quadrilateral rays which form appendages conspicuously seen at periods of great solar activity rapidly diminish, and at the distance of one solar radius have a small potential comparatively. The explanation of the long equatorial wings, with absence of well marked quadrilaterals, at periods of minimum activity, is due to the closing of the lines of force about the equator.

For detailed study the author applies his theory to the drawing of the corona by Professor Holden as observed during the total eclipse of Jan. 1, 1889; also to the photographs of same eclipse made by Professor Pickering. The results, to say the least, are suggestive, and possibly offer a clue to the explanation of the solar corona that is worthy of further critical study.

November Meteors. The night of November 16th last was very clear. A deep, dark, but brilliant sky presented itself and every object stood out wonderfully prominent. Twenty eight meteors were counted in one hour (about 9 to 10 P. M.) Two were of a decidedly bluish color. Nearly all proceeded out of the usual locality of the heavens already famous as a radiant point. My observation did not cover the previous evening, and only for about the hour of the evening mentioned. E J. BROOKINGS.

Washington, D. C., Dec. 1889.

Total Eclipse of Dec. 22 at Cayenne, South America. Mr. Charles H. Rockwell, who was in company with the Lick observing party at Cayenne, has very kindly sent us details of observations of the late total solar eclipse. Though given in a private letter we are sure our readers will enjoy most what he says in his own words as follows:

"It is a week to-day since the eclipse was seen here. Perhaps your regular correspondent at this point has already reported the success of our observations so that the notes of an occasional contributor merely repeat old news. The only party who did any work here was composed of Messrs. Burnham and Schaeberle, from Lick Observatory, and your humble servant. I did not bring any instruments, coming to see the country, and to put in the time on the way to California. There is only one regular communication a month between Cayenne and the world at large. I left Martinique on this regular steamer and was joined at Trinidad by Messrs. Burnham and Schaeberle, so that we arrived here in company on 30th November. As we approached our destination, the information which we received was not calculated to raise our spirits or to strengthen our hopes. We have struck the rainy season for this section, and rain here means business—no foolishness. However we went to work and were all ready for the event some days in advance. It rained steadily all night before the eclipse. We turned out before daylight; the rain had stopped, but the morning was so dark and cloudy as to give no hint which was east or which was west. In fact, we did not once see the sun until more than half an hour after first contact. Then came a short shower and a break in the clouds showed the moon covering two thirds of the sun's disc. Of course the atmosphere was charged with moisture—94 per cent is the normal condition of things here—but there was no cloud between us and the moon. All our work was in the line of photography—nothing else was attempted. Mr. Burnham used a six-inch equatorial from the Lick Observatory with the aperture reduced to three inches. Mr. Schaeberle had a Dallmeyer photographic telescope also of six inches belonging to the Naval Observatory—full aperture. I helped to manipulate an eighteen inch reflector belonging to Mr. Schaeberle which he fixed up in a most ingenious manner. Two pieces of joist 3 × 4 inches, 12 feet long, were held a foot apart by slats and braces. This was the backbone of the tube. Six or eight barrel hoops were nailed to the joists—these were the ribs—and over these was a covering of black calico. A barrel was sawn in two, ten inches from the head end, and so as to give a tub in which the reflector disc was packed. The elevation and azimuth were determined in advance and a screw was turned one revolution in ten seconds so as to keep the focus on the photographic plate. As it was wholly a volunteer move on the part of Mr. Schaeberle to bring this glass along, it seemed eminently proper that the volunteer observer should use it. If any results were obtained, well and good; if not, then no program was interfered with and no harm was done. We each exposed four plates and the whole twelve have turned out good. On some of them the curved rays of the corona are beautifully shown. Father Perry and his party were stationed on the Isle de Salut, about twenty-five miles off shore from here; they, too, had fair weather. A French amateur observer, Count de Baueve, was also on the island. He carried out instructions given him by M. Janssen as to the details of his work. He has not yet developed his plates. The governor of this colony, M. Gerville Roach, has treated us in the kindest manner possible, doing all in his power to aid us. The living here is poor enough, just sufficient to keep soul and body together. Messrs. Burnham and Schaeberle are in good health. I have been only tolerably well since coming ashore. We shall be glad to get away by the steamer of 3d January.

Cayenne, Dec. 29, 1889.

BOOK NOTICES.

THE ELEMENTS OF ASTRONOMY. A Text Book for Use in High Schools and Academies. By Charles A. Young, Ph. D., LL. D., Professor of Astronomy in the College of New Jersey. Boston, U. S. A., and London: Messrs. Ginn & Co., publishers, 1890; pp. 430. Supplement Uranography, pp. 42, with 4 double-page maps of the constellations.

Teachers or students who may be somewhat acquainted with the author's General Astronomy for Colleges and Scientific schools may have the impression that this new book is a mere abridgement of the other and large one. A careful examination of it, however, will correct any such erroneous notion, and will show that everything has been worked over and adapted to the needs of a High School course, as observed in the best schools of this class. The standard for the pupil is placed high, as probably many teachers will say as the new work is examined, and some may hastily conclude that it is too difficult for the place it is intended to fill, but we do not believe that to be a fair estimate of the book at all, nor a wise forecasting of what it will do if tried in the class-room in the hands of a live teacher. For one, we are glad to find one more author added to the short list of text-book writers who are able to make a book that has the power in it to stimulate thought, and to bring pupils out of habits of narrow and one-sided ways of looking at things, and to arouse in them a desire for further acquisition. At danger points the teacher must step in and regulate the aim of truth, to be sure, in all cases, that it do not overshoot the range of the pupil's intelligence. Another feature impresses us strongly. In an elementary text book some statements must be incomplete, but it is important that all should be correct and accurate as far as they go. Incompleteness of statement does not necessarily involve that which is false, although it sometimes happens that the two ideas are found in company in elementary studies. The experience and skill of the teacher are likely to divorce these natural enemies when he writes a text book for young minds which he has learned to know as others cannot appreciate them. The general order of the matter of this book is about the same as that of author's General Astronomy, and the arrangement of the topics in chapters is as follows:

1. Fundamental Notions and Definitions. 2. Fundamental Problems of Practical Astronomy. 3. The Earth. 4. The Orbital Motion of the Earth and its Consequences. 5. The Moon. 6. The Sun. 7. Eclipses. 8. Celestial Mechanics. 9. Planets in General. 10. The Individual Planets. 11. Comets and Meteors. 12 and 13. The Stars. Then follow three chapters giving supplementary matter to articles in the text, methods for determining the solar parallax, a description of astronomical instruments, tables of useful astronomical data, questions for review, and a general index.

We have before spoken in detail of the subject matter of the Author's General Astronomy and hence it is not necessary now to particularize in our review in the same way. For those who have seen neither book, it may be proper to say, that, in our judgment, both are books of very remarkable worth for the places they are respectively designed to fill. A final word may be added respecting the "suggestive questions" for use in reviews and Uranography. We want to call the attention of teachers to the free and frequent use of these queries and similar ones which they will suggest. Those who have not tried such exercises we believe, are not at all aware, what a rapid, lively run of such questions will do a student and turn the knowledge of the text-book to familiar, practical uses. Much in the same general way might be said of practice in the elementary study of Uranography. This text-book will help the live teacher and the willing student in such ways as these in addition to the ordinary modes of study.

ASTRONOMY, NEW AND OLD. By Rev. Martin S. Brennan, A. M., Rector of the Church of St. Thomas of Aquin, St. Louis, Mo., Author of "Electricity and Its Discoveries," and "What Catholics Have Done for Science." New York: Catholic Publication Society Co., 9 Barclay Street. London: Burns & Oates. Pp. 268.

The author suggests in the preface of this new book that its object is "to give an epitome of the vast science of astronomy in the simplest and most concise manner possible, and that he aims at the utmost fairness throughout the work and that particular care is exercised in this respect, in the treatment of the history and the different hypotheses of the science."

The title "Astronomy, New and Old," is an appropriate one, for the old astronomy is the most perfect of the sciences, reaching back through the times of the great Hipparchus to the dawn of tradition, while the new astronomy is of recent birth, scarcely yet twenty years old, but by its wonderful progress, a new field of brilliant and fascinating research has been opened that the author well names by the broad terms, the science of celestial physics.

This book contains sixteen chapters with the following titles, respectively: History; Division of Time and the Calendar; Spectroscope; Sun; Moon; Planets; Are the Planets Habitable?; Comets; Shooting Stars; Zodiacal Light; Starry Heavens, including (1) Constellations, (2) Stars, (3) Star Clusters and Nebulæ; Celestial Photography; Celestial Measurements; and Mechanism of the World.

The chapter on the History of Astronomy, consisting of 18 pages and covering a period from the time of the Chaldeans to the present, is concise, well written, and, so far as we notice, accurate in statement. The second chapter treats of the division of time and calendar. This is the best and clearest *brief* statement of these interesting themes that we have noticed in any modern book on the elements of astronomy. At almost a single reading the student is in possession of the facts about the calendar that he can easily remember and readily apply. Accompanying the chapter on the spectroscope is a full page plate, in colors, showing the spectra of the sun and three stars arranged for comparative study, and the brief account of the growth of science by the aid of the spectroscope, with the names of discoverers and the dates of their discoveries side by side, is a very useful run of historical information in convenient form for reference. The chapters on the sun, moon, planets, stars, and others connected indirectly thereto, are based on late researches, and give, in the main, the prevailing opinions of scholars of authority in their respective lines of study. In an epitomized treatment of so large a theme, it is almost unavoidable that incomplete statements will here and there creep into the text. We notice one such. On page 109 the velocity of light is said to be 185,000 miles per second as determined by the eclipses of Jupiter's satellites. By other and later proofs the accepted value is 186,330 miles. We did not notice this additional value elsewhere given in the book.

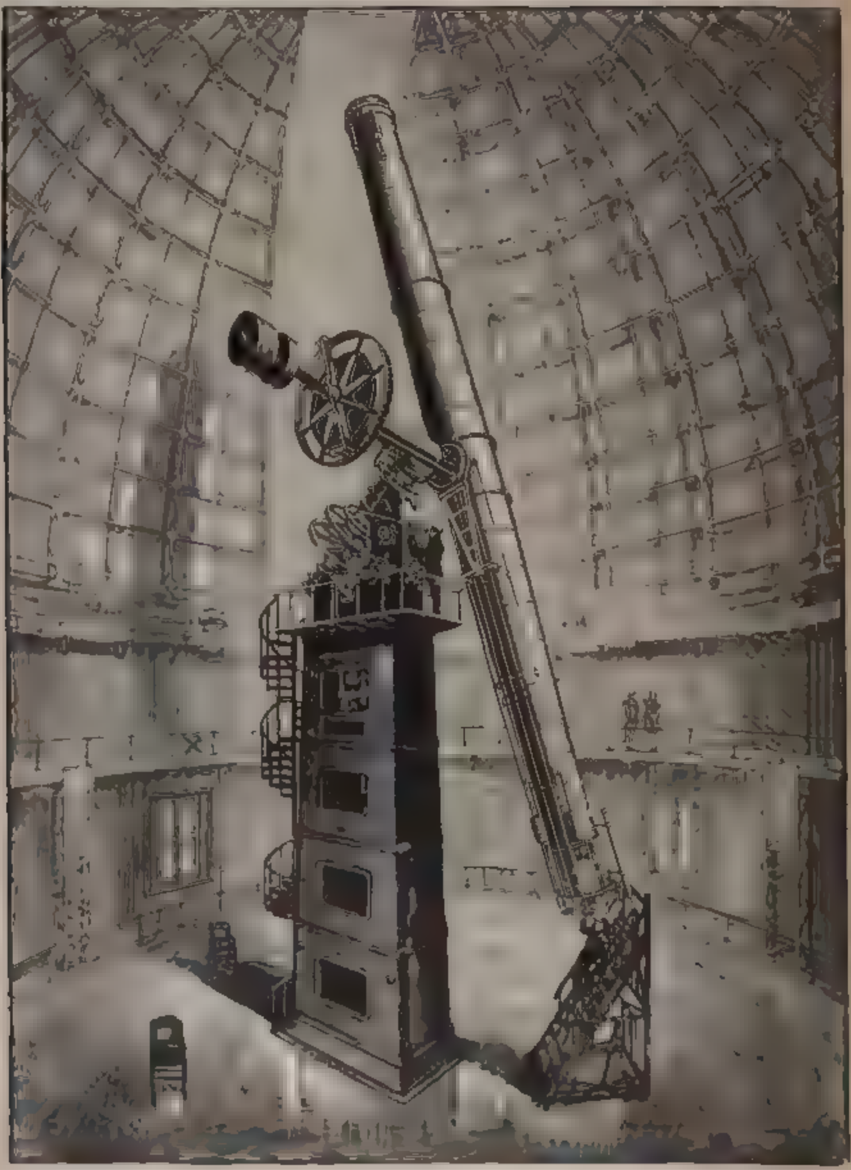
The topics of celestial measurements and the mechanism of the world are a plain setting forth of facts, methods and theories. We enjoyed reading the author's remarks on the latter theme especially. After a very full verbal quotation of the La Place theory or hypothesis, it is reviewed in a fresh, fearless way that evinces a comprehension of difficulties and a Saxon grip in statement that we think does not lack in dignity or force to claim the attention of thinkers and theorists themselves.

The new cuts from this book are from recent photographs by Professor C. M. Charroppin, S. J., St. Louis Observatory, and the Solar Eclipse party of Professor Pritchett, of Washington University, St. Louis, at Norman, California, Jan. 1, 1889. Attention is called to the advertisement of this book elsewhere given.

Books Received.

An Elementary Treatise Upon the Method of Least Squares. By GEORGE C. COMSTOCK, Director of Washburn Observatory, Madison, Wis., Messrs. Ginn & Co., Publishers, Boston, Mass.

The Elements of Differential and Integral Calculus. By T. A. SMITH, *Professor of Mathematics and Physics*, Beloit College, Wis.



WARNER & SWASEY
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OBJECT GLASS BY
ALVAN CLARK & SON

THE LICK TELESCOPE.

LENGTH 57 FEET DIAMETER OF OBJECT GLASS 36 INCHES
TOTAL WEIGHT 40 TONS

SIDEREAL MESSENGER,

CONDUCTED ... PAYNE

... CARLETON C... ... NORTHFIELD, MINN.

... MARCH ... WHOLE NO. ...

... GREAT TELESCOPE ...

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THE LICK TELESCOPE.

THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, No. 3. MARCH, 1890. WHOLE No. 83

THE GREAT TELESCOPE OF LICK OBSERVATORY.

To answer many queries that come to us from time to time from interested readers of THE MESSENGER, we have collected and give below, the principal facts concerning the equatorial telescope of Lick Observatory, which is now the largest and most powerful instrument of its kind in the world. Many of these facts have appeared in print before, but they are repeated in connection with some new ones, that the general reader may have at hand a brief and concise statement of them for ready reference.

By kindness of Messrs. Warner & Swasey, Cleveland, Ohio, we are able to give a fine cut of this great telescope for frontispiece to this number.

This noble instrument was completed in 1888, and placed on Mt. Hamilton, Santa Clara County, California, which is fifty miles southeast of San Francisco, and twenty-six miles east of San José. The elevation of the site above sea level is 4,209 feet and it commands a view of the southern end of the San Francisco Bay.

A few of the prominent features of the mounting of this telescope may next be named. The column is of cast iron 10 × 17 feet at the base, and 4 × 8 feet at the top, and weighs 20 tons. On this rectangular column rests the head, weighing 4 tons, into which is journaled the polar axis. Around this head is a balcony on which the assistant astronomer is stationed. By a system of wheels he is able to adjust the instrument for the study of any celestial object desired, and to read positions by microscopes illuminated by electric lights. The polar axis is made of steel, 12 inches in diameter, 10 feet long, and weighs 2,700 lbs. The declination axis is also of steel 10 feet long, and weighs 2,300 lbs. The tube is of steel, 57 feet long; its diameter being 4 feet at the center and 38 inches at the ends.

The tube complete with its attachments weighs 5 tons, and its motion in following a star is controlled by a driving clock which weighs one ton, and which is placed within the column and near its top, and within easy reach from a landing of the spiral staircase. The center of motion of the tube is 37 feet above the base, and when the telescope is pointed to the zenith the object glass is 65 feet above the base of the column. At the side of the great tube three telescopes are attached of apertures respectively 6, 4, and 3 in., which serve as finders. When the instrument is turned in declination the weight of the part of it in motion is 7 tons. When moved in right ascension the weight of moving part is 14 tons. The total weight of this great telescope is 40 tons.

The object glass was made by Alvan G. Clark, Cambridgeport, Mass., and has a clear aperture of 36 inches, a focal length of 627 inches and weighs in its cell 532 lbs. One second of arc at the focus is therefore about $\frac{3}{1000}$ of an inch, and the image of the sun at the focus is 6 inches in diameter. The photographic corrector is a lens of 33 inches clear aperture with a focal length of 550 inches. The photographic image of the sun is therefore $5\frac{1}{10}$ inches in diameter. Upon these images much work is done by the astronomer by the aid of special accessories such as the spectroscope, micrometer, photographic apparatus, etc.

The magnifying power which this instrument carries ranges from 180 to 3,000 diameters. Professor Holden has remarked on this point that, "While the magnifying power which can be successfully used in a five-inch telescope is not more than 400, the 36 inch telescope will permit a magnifying power of more than 2,000 diameters on suitable objects, stars for example. This power can not be used on the moon or planets with real advantage for many reasons, but probably a power of 1,000 to 1,500 will be the maximum. The moon will thus appear under the same conditions as if it were to be viewed by the naked eye at the distance of say 200 miles. This is the same as saying that objects 300 feet square can be recognized. So that no village or great canal, or even large edifice can be built on the moon without our knowledge. Highly organized life on the moon will make itself known in this indirect way if it exists."

We have just received "Notices from the Lick Observatory," prepared by members of the staff, in which appear an abstract of a paper by Mr. Keeler on the *Efficiency of the Great Equatorial*, which is given here in full as follows:

EFFICIENCY OF THE GREAT EQUATORIAL.

The following extract from a paper by Mr. Keeler summarizes the opinions of the astronomers of the Lick Observatory upon the performance of the great telescope, and may be of general interest:

. . . "As the large telescope has now been sufficiently long in use for a thorough test of its various qualities, it may be worth while to give a brief summary of the different kinds of work in which it has proved to be effective.

"*Separation and measurement of close double-stars*, as attested by the long list of new doubles, and micrometer measurements of these and of difficult pairs already known, published by Mr. Burnham.*

"*Detection of very faint stars*. Professor Holden and Mr. Schaeberle have observed six stars within the dark interior space of the ring nebula in Lyra, besides the central one (No. 14 of Lassell's drawing), and five more within the nebulosity,† and of all these, only the central one was previously known. An example of a double-star with extremely minute components discovered with this telescope, is the pair preceding the trapezium in the nebula of Orion.‡ It was found by Mr. Barnard; and Mr. Burnham, who measured it, considers it the most difficult pair with which he is acquainted in the whole heavens.

In this connection may also be mentioned the observations of the satellites of Mars,§ made here during the opposition of 1888. When Mars was in opposition the satellites were easy objects, being plainly visible without the aid of an occulting bar to hide the planet, and they were seen as late as July 18th, when their brightness was only 0.12 of that of their discovery in 1877.

"*Observations of the structure of the nebulæ.* The Lyra nebula has already been mentioned under the preceding

* *Astronomische Nachrichten*, (Nos. 2929 and 2930).
† *Monthly Notices*, R. A. S. (Vol. XLVIII, No. 383).
‡ *Monthly Notices*, R. A. S. (Vol. XLIX, No. 6).
§ *Astronomical Journal*, (No. 178).

division, but only in relation to the minute stars which appear in it The structure of the nebula itself was better seen by Professor Holden with this instrument than with any other that he had used. He says: 'One's first idea is not so much that the aspect is unfamiliar as that it is distinctly different; that its simple structure has suddenly become complex; and, finally, that the task of depicting it completely is practically impossible by the ordinary methods.'* The observations which show the probable existence of helical forms in the nebulæ† should also be mentioned.

"*Observations of comets.* The companions of Brooks' comet have been observed and measured during the past few months by Mr. Barnard, who finds a considerable advantage in the thirty-six-inch over the twelve-inch refractor.‡ With the latter instrument the faint companions, called by Mr. Barnard *D* and *E*, were at all times invisible, although for blackness of field and excellence of definition the twelve-inch telescope is unsurpassed.

"*Definition of the surface features of a planet.* The views of *Jupiter* obtained here during the past opposition have sufficiently proved to all the observers that the large telescope is as suitable for the observation of planetary details as for the other classes of work above given. The extremely fine division, discovered by the writer, in the outer ring of *Saturn*, out side of the Encke shading,§ has been seen by all the observers here on numerous occasions, but, so far as I am aware, it has been seen at no other place. Finally, I may refer to observations by Professer Holden, not yet published on details seen in specially interesting parts of the lunar surface.

"These different classes of astronomical work essentially cover the field of visual observation, and in all the thirty-six-inch refractor has shown its capability of yielding the best results."

The possibilities of this instrument, by the aid of its photographic apparatus, are probably very much greater; but how much greater we are not yet able to say, as the instru-

* *Monthly Notices* R. A. S. (Vol. XLVIII, No. 9, p. 385).
† *Publications of the Astronomical Society of the Pacific* (No. 3), and *Himmel und Erde*, October, 1889.
‡ *Astronomische Nachrichten*, (No. 2919.
§ SIDEREAL MESSENGER, (No. 62) *Astronomical Journal*, (No. 190), *Ciel et Terre*, 2e serie, t. V. 1889.)

ment, so far as we know, has not yet been put to a full and general test of its powers in the varied field of difficult photographic work.

THE PROGRESS OF ASTRONOMY IN 1889.

At the beginning of this, the last decade of the century, we propose, according to our annual custom, to furnish a short précis or chronicle of the astronomical occurrences of the year just departed; and to put on record such observations, discoveries, investigations, and events as concern the history and progress of astronomy generally.

The year 1889 opened with a phenomenon of high astronomical interest, the total eclipse of the sun on January 1st, which was most excellently observed in California. Particularly successful were a large proportion of the very numerous photographs of the corona obtained by the various parties of observers, and among them those secured by the party from Harvard College Observatory, under the direction of Professor Pickering; the ones taken by Mr. Barnard, of the Lick Observatory; the negatives obtained by the party from Washington University (St. Louis); and last, though by no means least, those of the Amateur Photographic Association of the Pacific Coast, under the able direction of Mr. Charles Burckhalter. The result has been entirely to corroborate the theory that, during the period of sun-spots, the corona undergoes a series of characteristic and typical changes. Incidentally we may mention that Mr. Keeler, of the Lick Observatory, also demonstrated the untenability of the hypothesis of Professor Hastings that the corona is a phenomenon of diffraction.

Careful preparations were also made for the effective observation of the total eclipse of the sun, which occurred during the morning of December 22. Two expeditions were organized by the Royal Astronomical Society. The members of the first, the Rev. S. J. Perry, F. R. S., and his assistant, Mr. Rooney, proceeded to the Salut Islands. Mr. Taylor went alone, on the second, to Loanda. An American expedition, headed by Professor D. P. Todd, was also dispatched to Angola by the Navy Department at Washington; while two

of the Lick observers went to Cayenne. Miss E. Brown and Miss Jefferies were to view the eclipse from Trinidad. Up to the moment of our writing, the sole news which has reached this country from any of those whom we have mentioned has taken the shape of a telegram from Mr. Taylor, unhappily announcing his own total failure to see anything of the phenomenon which he had travelled so many thousands of miles to witness. We can only express our earnest hope that other observers may have been more successful.

The occultation of Jupiter by the moon in the evening of August 7 was successfully observed at numerous stations. Curious effects of shading on the planet's limb, and adjacent to that of the moon when she crossed Jupiter's disc, were seen by a large number of those who witnessed the occultation.

The conjunction of Mars, Saturn, and Regulus during the early morning of September 20 was looked forward to with considerable interest, as calculated to shed light upon the nature of certain pre-telescopic observations of planetary conjunctions; but, unfortunately, our wretched English climate rendered its observation practically impossible over nearly the entire kingdom.

On March 6, that well-known observer, Dr. Terby, of Louvain, noticed a white spot on Saturn's rings contiguous to the shadow of the ball This was also seen by Mr. W R. Brooks at Geneva (New York), subsequently *Malgre*, however, the concurrent testimony of two such competent astronomers, there can be little or no doubt that the appearance was a wholly subjective one, inasmuch as it was invisible in such enormous and powerful instruments as the mighty Lick refractor and Mr. Common's famous five-foot reflector.

We referred last year (Vol. XLVIII. p. 368) to the researches of Mr. Crew on the solar rotation period. To meet certain objections to the method he employed, he has repeated his observations, after taking special precautions against the heating of the jaws of the slit of his spectroscope His final results are sufficiently startling, giving as they do a period of 26 23 days as that occupied by the sun in turning on his axis, against the 24.79 days of Carrington

and Spöerer. But the question can in no sense be regarded as settled.

It has been erroneously supposed that the question of the possibility of photographing the corona of the uneclipsed sun was disposed of by Dr. Huggins's failure to obtain good negatives in 1886; but there can be no doubt that the absence of an absolutely clear sky in England (save on the very rarest possible occasions) may be held to explain this. On April 12th, 1888, however, he did succeed in obtaining a photograph which if it does not really exhibit the corona, is a marvelous example of an optical illusion. His method is to be tried in the diaphanous atmosphere of Athens by Eginitis, the astronomer in charge of the Observatory there; and experiments were probably made also by one or more of the observers in the eclipse of December 22.

A question which has excited some discussion has been finally set at rest by the joint investigations of Dr. Huggins and his gifted wife. It must be familiar to many who will read these lines that Mr. Lockyer insisted that the chief line in the spectrum of the great nebula in Orion was simply the edge of a fluting of that of magnesium at a comparatively low temperature. Dr. and Mrs. Huggins have now shown conclusively that this is an entire mistake, and that this line belongs to some, so far, unknown body. The researches of Dr. Huggins on the principal line of the auroral spectrum have also had the effect of correcting another mistake of Mr. Lockyer's; that gentleman having referred it to the brightest fluting of manganese at wave-length 5580; while Dr. Huggins, with the most perfect apparatus employed with that skill which has earned him such imperishable renown, has finally determined its wave-length to be 5571.5. Lastly, it was suggested by Mr. Lockyer that the dark bands seen in the spectrum of Uranus by Huggins, Secchi, Vogel, etc., were merely spaces between the flutings of a radiation spectrum. Mr. Keeler, of the Lick Observatory, employing the giant 36-inch telescope, finds that the bands are actual absorption ones, and could see that the spectra of the satellites Oberon and Titania were continuous!

The remarkable researches of Professor Pritchard in Stellar Parallax, by means of photography, have been continued during 1889, and the results so far obtained were published

some two months since, in Vol. III. of the "Astronomical Observations made at the University Observatory, Oxford." They shed a new light upon the physical structure of the visible universe.

Commencing in 1884, and working on every available occasion since, Dr. Boeddicker, Lord Rosse's assistant astronomer, has produced a series of drawings of the whole of the Milky Way visible in these latitudes, which is as unsurpassed as it is probably unsurpassable in the elaborate character of its minute detail. It is verily a marvel of the most minute and patient accuracy, and cannot fail materially to advance our knowledge of the fabric of our stellar system. Dr. Boeddicker's astonishing drawings are deposited in the library of the Royal Astronomical Society, until some effectual means can be devised for their reproduction.

Seven Comets have been discovered during the year which has just closed. The first (*a*) was found by Brooks at Geneva, N. Y., on January 15th; the next (*b*) by Barnard, at Lick, on March 31st, the third (*c*) also by Barnard, on June 23rd; the fourth (*d*) by Brooks, on July 6th; the fifth (*e*) by Davidson, at Melbourne, on July 21st; the sixth (*f*) by Lewis Swift, on November 17th; and the seventh (*g*) by Borrelly, at Marseilles, on December 12th. None of these objects attained to any conspicuous brilliancy, the only circumstance worthy of note in connection with them being that Brook's Comet (*d*) divided into two parts.

By a coincidence, seven is also the number of Minor Planets picked up in 1889 To Palisa belongs the credit of finding the first (282) on January 4th; Chairlois discovered 283 on January 28th; 284 on May 29th; and 286 on August 3rd; Palisa picking up 285 on the same day. Peters found 287 on August 25th, since which there has been a lull in these absolutely useless discoveries.

In connection with the Bibliography of Astronomy, we must place that admirable work, Young's "General Astronomy," at the head of our list, as the most worthy successor to Sir John Herschel's "Outlines" that has yet appeared. Students of planetary detail will find much of a most instructive nature in Boeddicker's "Observations of the Planet Jupiter," Green's "Belts and Markings of Jupiter, and very

notably in that remarkable and exhaustive book "Zenographical Fragments," by Mr. Stanley Williams. Two works, each of high interest in very different ways may be commended to those interested in physical astronomy, they are "Elementary Theory of the Tides," by Abbott, and "Time and Tide," by the Irish Astronomer Royal, Sir R. S. Ball. The first treats the theory of the tides mathematically, but in a simple, apprehensible, and what is of grave importance, absolutely correct form. The second, a popular exposition of Prof. G. H. Darwin's researches, is as interesting as a good novel. The first volume of the new edition of Chambers's "Handbook of Astronomy," has recently appeared. As has been observed by one of our own correspondents this has now become a veritable encyclopedia of the science, and almost indispensable as a book of popular reference. Nor must we omit Mr. Cottam's splendid "Charts of the Constellations," than which nothing finer of the kind has ever appeared.

Death has happily claimed but few distinguished Astronomers as his own during the late year. The first to pass away was Dr. Warren de la Rue, who will long be remembered as the pioneer in English astronomical photography; as a skilled practical observer; and as a man who, both in purse and in person, was unsparing in the promotion of astronomy. He furnished a bright example of a class (erroneously supposed to exist only on the other side of the Atlantic) who munificently devote no inconsiderable portion of their fortunes to the advancement of science. Mr. R. S. Newall, who died within a very short time of Dr. de la Rue, was less known as an astronomer than as the possessor of a very big telescope. This has, it is understood, been presented to the University of Cambridge, who are to house and employ it. We last year announced the retirement of Miss Maria Mitchell from the Professorship of Astronomy at Vassar College, New York. She died in July, 1889. Professor Cacciatore also died at Palermo in the same month. Earlier in the year Wilhelm Tempel, of Florence, after a protracted illness, was taken. One of the most familiar names among those who have joined the majority is that of Professor Elias Loomis, whose "Practical Astronomy" is to be found probably in every Observatory in which the English

language is legible. His somewhat less familiar "Treatise on Astronomy" forms a model work of reference.

Among miscellaneous astronomical facts and occurrences may be mentioned the appointment of Dr. Ralph Copeland as Scottish Astronomer Royal, and the projected erection of a new and efficient Observatory in the outskirts of Edinburgh. The founding and rapid rise of the Astronomical Society of the Pacific tends to remind us of the allied success of the Liverpool Astronomical Society in this country. The Californian institution, however, possesses the enormous advantage of its intimate connection with the Lick Observatory on Mt. Hamilton, the results of the work at which it has the privilege of making public through its Transactions. We may also notice the removal bodily of the Observatory and instruments of our great astronomical photographer, Mr. Isaac Roberts, from the dingy, cloud-laden atmosphere of Liverpool to the clearer sky and considerable altitude of Crowborough Beacon in Sussex. All familiar with the marvellous results obtained by Mr. Roberts under every possible meteorological disadvantage, will look forward with eager hope to his future triumphs under more favorable conditions. An elaborate remeasurement of the French Arc of the Meridian, completed as far as actual instrumental observations were concerned in 1888, has been to a great extent reduced during the past year. It differs by less than $\frac{1}{300000}$th from the results of the English, Belgian, Italian and Spanish triangulations—a striking illustration of the precision of modern methods of observation. Incidentally a redetermination of the difference of longitude between Dunkerque and Greenwich has been effected but the final result has not as yet been made public.—*English Mechanic, Jan. 3, 1890.*

ASTRONOMICAL SOCIETY OF THE PACIFIC.

CHARLES BURCKHALTER, SECRETARY

For The Messenger

The meeting of the Astronomical Society of the Pacific Jan. 25, 1890, was held at its rooms in San Francisco President Holden was unable to be present on account of

the storm and ill health. Mr. Keeler came from the Observatory on Mt. Hamilton purposely to attend the meeting, walking seven miles of the distance through the snow which was five feet deep in places. In the absence of President Holden, Vice President Pierson presided. The meeting was largely attended.

The secretary read a list of seventy-five presents of books, etc., calling attention to two large drawings of Jupiter twenty-eight inches in diameter. The thanks of the Society were voted to the donors.

The chair announced the success of the eclipse party of the Lick Observatory which was sent to South America at the expense of Col. C. F. Crocker. It was also announced that the Board of Directors had, with the approval of Alexander Montgomery, determined to expend $1,000 of the Alexander Montgomery Fund to found a library, to be known as the Alexander Montgomery Library of the Astronomical Society of the Pacific, and that the remainder of the fund ($1,500) should be invested and the income only to be used in preserving and enlarging the same.

Twelve new members were elected, as follows:

W. Steadman Aldis, Auckland, New Zealand; Jose A. y Bonilla, Zacatecas, Mexico; A. R. Church and Hugh Howell, Oakland, Cal.; Mateo Clark, London, England; Levi K. Fuller, Brattleboro, Vt.; Frederick G. Wattles, Denver, Col.; Professor M. W. Harrington, Director Ann Arbor Observatory, Ann Arbor, Mich.; Professor Ira More, Los Angeles, Cal.; T. S. Palmer, Washington, D. C.; James L. Scott, Shanghai, China; P. V. Veeder, D. D., San Mateo, Cal.; Adolph Sutro, San Francisco, Cal. Messrs. Clark and Sutro were made life members.

Mr. James E. Keeler then read a paper "On the Physical Observations of Jupiter in 1889," in which Mr. Keeler exhibited a series of twenty-four drawings of Jupiter, made during the opposition of 1889, with the thirty-six-inch equatorial of the Lick Observatory. The drawings were made on a large scale, the elliptical outline of the planet being 3.50 × 3.30 inches, and were intended to show all the details that could be perceived with the telescope and transferred to paper in the limited time allowed by the rotation of the planet (about fifteen or twenty minutes). All dimen-

sions were mere eye-estimates, but they had been checked by micrometer measurements, and found to be fairly accurate. Reference was made to the extremely satisfactory views obtained with the great telescope and a *resume* given of the different kinds of astronomical work in which the instrument had proved to be efficient.

The equatorial zone of Jupiter was brilliant white at the edges, with a salmon-pink central stripe, which the measurements showed to be a trifle south of the equator. From the edges of the zone long streamers projected at certain places into the red belts, with which they eventually became parallel, and gradually becoming more diffuse, were lost in the general red color of the background. These streamers which are doubtless the cause of the double and triple red belts, often described, were, according to the observations, masses of clouds projected outward from the equatorial zone, and gradually left behind by the forward drift of that region. Two were frequently seen abreast, but never three. The roots of the streamers were never brighter than the average surface of the equatorial zone, and were usually tinged with a curious olive-green color, which seemed to be characteristic of great disturbance. At certain parts of the equatorial zone, the streamers were sometimes considerably distorted, but when long they invariably pointed toward the following limb of the planet. Observations of bright knots on the streamers showed that there was a flow of matter along them from the root outward.

The red spot was frequently well seen. It was shorter than in 1881. The color was a pale pink, lighter in the middle of the spot. At the following end the outline was marked by a faint dark shading.

On a broad, uniformly tinted, gray belt on the southern hemisphere, following the red spot, were many oval and round brilliant white spots, forming one of the most beautiful features of the surface of Jupiter. A curious symmetry was often observed in the grouping of these spots, which are shown in nearly all the drawings.

On the northern hemisphere the details were much simpler, and the belts were of the usual form. Bright white spots like those described above were never seen. As in former

years the greatest activity seems to be manifested south of the equator.

This was followed by a paper entitled "A New and Simple Form of Electric Control for Equatorial Driving Clocks," also by Mr. Keeler. This ingenious contrivance is attached to the driving clock of the great refractor of the Lick Observatory, and is giving great satisfaction.

A committee was appointed to nominate a ticket to be voted for at the annual meeting (March 29th).

The meeting then adjourned to March 29th.

THE RELATIVE ACTIVITY IN THE TWO SOLAR HEMISPHERES.

EDWIN B. FROST.*

FOR THE MESSENGER.

Professor Spoerer called attention in Astronomische Nachrichten, No. 2887, to the difference in the activity in producing spots of the two solar hemispheres between 1883 and 1888, and Professor Riccò of Palermo followed, in No. 2919, with a similar discussion of the prominences. It appears that spots have been much more numerous in the southern hemisphere, the ratio being 20 : 11 for the whole period, while the separate ratios for 1887 and 1888 were much larger being 2.3 : 1 and 3.4 : 1 respectively.

From observations on 203 days in 1889, using the 9.4-inch equatorial and a projected image of 8 inches diameter I obtain the following results:

Northern Hemisphere,	6 groups,	24 spots,	mean latitude of spots $+\ 9^{\circ}.6$
Southern "	18 "	98 "	" " " " $-14^{\circ}.5$
Total	24 "	122 "	

The preponderance of spots in the Southern Hemisphere has thus continued during the past year, and with a slight increase, the ratio for spots being 4.1:1 and for groups 3:1.

The period of this swing in activity from one hemisphere to the other, if it can be said to be truly periodic, does not seem to be determinate from the data at present available. The mean latitude of spots, which since 1879 has been

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* Director of Shattuck Observatory, Dartmouth College, Hanover, N. H.

steadily decreasing, has increased during 1889,—an indication that the minimum is very nearly, if not quite passed. Dr. Spoerer gives for the mean latitudes in 1888 + 5 .9 and — 6°.9, and the Greenwich observations + 7°.1 and — 7°.5. The values which I give above, + 9°.6 and — 14°.5, are the means of the latitudes of the chief spot of each group, which may be assumed to represent on the whole the mean latitudes of all the spots.

The conclusion of a period of minimum activity is also generally signalized by the appearance of spots in high latitudes. On June 30th and July 1st, I observed a small spot in the remarkable latitude south 42°; this spot was elsewhere observed in Europe, but was overlooked on the Greenwich photographs until Father Perry called attention to it. On October 22 I saw a faint dot, which possibly ought to be classed as a veiled, rather than a true, spot in north latitude about 51°.

From observations of the whole circumference of the sun on 83 days in 1889 I find a preponderance of prominences (none under 20″ in hight being included) in the Southern hemisphere, similar to that in the case of spots.

The distribution in latitude is as follows:

	North.	South		North	South
80° — 90°	5	2	30° — 40°	6	21
70° — 80°	1	4	20° — 30°	10	12
60 — 70	3	6	10° — 20°	7	15
50 — 60	8	8	0° — 10°	6	10
40° — 50°	11	18		—	—
			Totals	57	96

A distinct maximum is shown between 30° and 40° south; the mean latitude of northern and southern prominences falls between 30 and 40 , that for the northern being slightly the greater.

The ratio of southern prominences to northern is 1.68. It is proper to say that the position angles, from which the latitudes are deduced, have not been directly measured but have been estimated with the aid of the position circle of the telescope.

Professor Riccò's tables show that prominences have been most abundant in the southern hemisphere since 1884, with the single exception of '86; the ratio of southern to northern prominences he found to be for 1888, 3 : 1.

The small value, 1.84, of the mean number of prominences per observation indicates that the chromospheric activity is also near a minimum.

Further evidence of this is given by the quiescent character of the prominences, which have been found almost invariably of the diffuse hydrogen type. The largest one seen was visible on four days, Nov. 15-18, in S. lat. 49°, and remained at an altitude of about 100.″

DARTMOUTH COLLEGE, Hanover, N. H., Feb. 5, 1890.

TRANSIT OBSERVATIONS BY PHOTOGRAPHY.

WILLARD P. GERRISH.

For THE MESSENGER.

A paper read by Mr. W. E. Wilson before the Royal Astronomical Society at its meeting, December 13, 1889, calls attention to a device for taking transit observations by photography. It may be of interest to note that experiments were made at Harvard College Observatory as early as January, 1886, on the plan proposed by Mr. Wilson. Photographs were made of the Pleiades with the eight-inch Bache telescope with view of determining the degree of accuracy with which time could be determined. The star images were allowed to trail over the plate, the telescope remaining at rest. Exposures of different lengths were given and the images were afterward measured. The discussion showed that a single setting on an image made by an exposure of one second could be made with a probable error of only $0^s.03$. An account of this work can be found in Memoirs of American Academy, Vol. XI, p. 218.

The subject was again taken up in the summer of 1888 and experiments were continued by Professor F. H. Bigelow and the writer. A photographic plate was attached to a common telegraph sounder and placed at the focus of a six-inch telescope. The plate was moved with an alternating motion at intervals of one second in a plane perpendicular to the axis of the telescope. The direction of this motion was parallel to the meridian. The star image was allowed to trail across the plate by the diurnal motion. Two rows of dots were thus formed, each dot representing one second of time.

After these preliminary experiments Professor Bigelow constructed an experimental apparatus more especially adapted to the work. This was used with the same telescope and gave very good results. It was fitted with a small plate holder which was connected with the armature of a magnet by which the motion was imparted. A reticule of raw silk fibres was placed at the focus of the telescope, and an impression of this reticule was made on each plate by throwing the light of a lantern into the objective for an instant, slightly fogging the plate. The wires appeared as distinct light lines on a slightly darkened background, though not sufficiently dark to obscure the star images. An attempt was made to operate the instrument directly from the sidereal clock of the Observatory. The clock has an ordinary break-circuit attachment, and the signal was found to be of so short duration that it made no appreciable break in the star trail.

In the autumn of the same year a complete set of apparatus of fine workmanship was constructed from the plans of the writer. It consists of two separate and independent instruments, one being designed to transform the signals of an ordinary clock into alternating signals, and the other being a small tail-piece carrying the magnet and mechanism to be attached to the transit instrument.

The alternating machine is not unlike an ordinary telegraph relay in appearance. A large magnet in the circuit of the standard clock actuates an armature lever which has at its upper end a pawl engaging the teeth of a ratchet wheel. The wheel moves one tooth at a time with each movement of the armature and turns a contact wheel. Upon this rests a spring completing a local circuit operating the mechanism on the telescope. Alternate sections of the contact wheel are cut away, so that the local circuit is alternately opened and closed with each signal on the clock circuit. A second contact wheel on the same arbor with the first is cut away, to give signals of two seconds duration, for use on northern stars where the one second interval would make the images too near together. A switch serves to send the local current through either of these at the will of the observer.

The tail-piece consists of a brass box 4 inches long, 2½ inches wide, and 1⅜ inches deep, weighing with its contents and attachments 17½ ounces. It has on its side an opening

which fits the adapter of the telescope. In this box is a small electro-magnet, to the armature of which is attached a small, square photographic plate measuring 1¼ inches on a side. The plate is held in position by a spring clamp which prevents any accidental slipping. The plate has a motion of about 0.01 inch, the amount being regulated by two adjustable stops between which the armature vibrates. The frame, or clamp, carrying the plate is hung on a system of parallel levers similar to a parallel ruler, and so arranged that it can move only in a direction parallel to the meridian. All of the bearings are hardened steel points, fitted with springs to take up all lost motion and to prevent the plate from changing its position after having been once adjusted. An important feature of this portion of the apparatus is that the plate is clamped directly to the armature lever of the magnet, without the interposition of a plate holder. This greatly reduces the chance of error from the slipping of the plate. As the reticule is rigidly and permanently attached to the telescope, it is only necessary that the plate should remain accurately in place during the observation until the impression of the reticule is finally made upon it. The brass box serves as a plate holder, being so small and light that it can readily be detached and carried to the dark room to be recharged with a fresh plate. A small slide which covers the opening in the box serves to exclude the light when it is detached from the telescope.

A small three inch transit instrument was chosen for the work and the apparatus was fitted to it. Observations were made on several of the brighter stars, but owing to the small aperture of the telescope, stars fainter than the third magnitude could not be taken. An instrument for use with the device should have a very large angular aperture.

OBSERVATORY LOCAL PATRONAGE

LETTER FROM PROF. H. S. PRITCHETT.

Editor of the Sidereal Messenger:

In your February number appears a communication from Capt. Phythian, U. S. N., Superintendent of the Naval Ob-

servatory, in which two personal letters of mine are printed. I do not think that the personal part of Capt. Phythian's letter calls for a reply from me, further than to say, that I had nothing to do with furnishing the information which called out the article in the December number of THE SIDEREAL MESSENGER, to which I understand Capt. Phythian's letter to be a reply.

Since the matter is under discussion it may not be out of place to call attention to one or two matters which I think involve the real question at issue, and which Capt. Phythian has apparently overlooked in his letter.

1. The tacit agreement originally entered into between the Naval Observatory and the Western Union Company did not contemplate that the company should have a monopoly of the government time-signals, nor that it should become a trafficker in time-signals; still less that it should use the time-service of the Naval Observatory to destroy the service for years carried on by private Observatories.

2. The furnishing of time-signals to the Western Union Company for its own use is one thing; the furnishing of these signals to that company to serve as a basis of a commercial service is quite a different matter. The Western Union Company recognizes this distinction the moment the signals come into its hands. When it furnishes the Naval Observatory time-signals to a customer he signs a contract in which it is "expressly stipulated" that he shall not "cause or suffer the signals to be transmitted to any point other than said office," meaning thereby the office of the subscriber. This prudent restriction is necessary on the part of the company in order to keep the traffic in the Observatory signals in its own hands.

Now, while the Naval Observatory may with perfect propriety furnish time-signals to the Western Union Company for its own use (and to this no one, I think, has offered objection), it is certainly questionable whether it is the proper work of that institution to become the basis of a commercial service through that company.

So far as this Observatory is concerned the preservation of the time-service is a matter of great importance. Time-signals have been sent from here for some years to a large number of roads, some of which have paid moderate amounts

for the signals, a large number paying nothing. From the revenue of the service the Observatory as it now stands has been chiefly built and furnished with instruments, and from the same source its current expenses including the pay of an assistant, are almost entirely met. For some years an earnest effort has been made in this city to build and endow a large Observatory. In a business city like St. Louis the maintainance of some public service like a time-service, is almost indispensable for success in such an effort. The time-service as maintained here has been in the largest sense a public service, and carried on with the end in view just mentioned. Within the past few months it has been displaced in some quarters by the Naval Observatory service in the hands of the Western Union Company. So far as I can see the whole service is likely to share the same fate, for even with other things equal, it is scarcely possible for a private Observatory to compete in prices with a corporation which receives its time service ready-made and free of expense.

The attitude of the Western Union Company towards scientific institutions has always been understood to be of the most friendly character. The wires of the company have frequently been used free of charge by the Observatories in longitude exchanges and other scientific work. From the labors of Henry, Morse and others, the company has received on its part a large return. Furthermore the telegraph company has had the use, so far as I know, of the time-signals of the private Observatories. This has been the case at least with the signals sent from this Observatory. In some cases the Western Union Company has transmitted our signals to subscribers, and collected money in which this Observatory has never sought to share. In fact it has been assumed that it was to the interest of the telegraph company to befriend, so far as business interests allowed, the Observatories. When, however, a superintendent of that company writes to the manager of a railroad receiving time-signals from our Observatory urging him to discontinue this service, it is somewhat difficult for the directors of Washington University to look on such action as an act of friendship to scientific institutions; and when the Superintendent of the Naval Observatory continues to furnish the telegraph company the means for displacing our service, knowing the

the use for which they are intended, it is only with considerable effort that we are able to look upon this action as "an effort to use this Observatory" (the U. S. Naval Observatory) "in forwarding the interests of other Observatories."

With regard to the whole question it may be said in brief that the interests of the private Observatories and the Western Union Telegraph Company in the matter of the public service ought to be identical—the telegraph company serving as a transmitter of time-signals originating at the Observatories. It surely ought to be possible to come to an understanding under which the rights of the Observatories as time centers and the rights of the telegraph company as time transmitters should be equally conserved. It cannot be doubted that the interests of the public lie, not in the direction of a conflict between the company and the Observatories, but in their coöperation. It will be a matter of public loss if any other solution of the matter is attempted. In either case American Astronomy will be the loser if this matter is allowed to disturb that *entente cordiale* which has always existed, and which it is so necessary should exist, between the Government Observatory on the one hand and the private Observatories on the other.

I am very truly,

H. S. Pritchett.

St. Louis, February 18, 1890.

NOTICES FROM LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF

Return of Lexell's Comet

The news of a remarkable and extremely important discovery in cometary astronomy, made by Mr. S. C. Chandler—so well known as a mathematician and astronomer—has just been received. Mr. Chandler has just completed a preliminary examination into certain peculiarities of the orbit of the comet discovered in July last by Mr. Brooks, and which is still under observation.

This comet has been found to revolve in an elliptical orbit about the sun in seven years It has attracted particular

attention through the discovery, at the Lick Observatory, of the remarkable companion comets that attend it in its journey through space.

Before speaking of Mr. Chandler's discovery, it will be necessary for us to go back, in time, over one hundred years, to the date of the discovery of Lexell's comet, in 1770. Upon the computation of the orbit of this comet, Lexell found it to be revolving about the sun in a period of five and one-half years. This was considered remarkable, for the comet was visible to the naked eye, and, therefore, ought to have been seen at some of its former returns. But it had never been seen before—nor, indeed, since.

Lexell found that the aphelion of this comet was very close to Jupiter, and that it had made a very close approach to that planet in 1767. He also found that, previous to 1767, the comet had moved in an orbit whose perihelion was near Jupiter, and its distance, therefore, so great that it could not be seen from the earth. At this near approach to Jupiter in 1767, the planet's attraction on the comet was three times as great as the sun, and the comet, therefore, remained in the vicinity of Jupiter many months, its orbit becoming completely changed, so that when it finally was freed from the overpowering influence of the planet, it was thrown into a much smaller orbit, in which it would make a revolution in five and one-half years. In this small orbit it approached very near the earth, and was visible to the naked eye. At its nearest approach to the earth in 1770 it was less than one-half million miles distant. So close was the approach, indeed, that La Place computed that if the comet had any considerable mass, it would have seriously disturbed the motion of the earth in its orbit, and if the mass had been equal to that of the earth, it would have shortened the length of our year by something like three hours. From the fact that no sensible disturbance was experienced from the proximity of the comet, La Place concluded that its mass was certainly less than the one-three-thousandth part of the mass of the earth, or less than one-fortieth of the mass of our moon. It was, doubtless, vastly smaller than that.

In 1779 the comet made a still closer approach to Jupiter, and at that time the attraction on the planet was over two

hundred times as great as that of the sun, and the orbit was again changed, the perihelion becoming so great that the comet could not be seen from the earth. Burckhardt, who verified Lexell's calculations, found that before the comet came under the influence of Jupiter in 1779, its perihelion distance was probably 5.08, while that of the small orbit of 1770 was 0.67, and after the disturbance through its proximity to Jupiter, in 1779, its perihelion distance probably became 3.33, the distance of the earth from the sun being assumed unity. This body, because of its never having been seen since 1770, has been called the *lost comet*, and it has stood as the most remarkable example that we have of planetary influence in disturbing the motions of comets.

We will now return to Mr. Chandler's investigations. He found that Brooks' comet must have made a remarkably close approach to Jupiter in 1886, and that the attraction of the planet then threw the comet into its present orbit, whatever may have been its path previous to that time. This led him to suspect the identity of this comet with the famous Lexell comet of 1770, and he, therefore, attacked the problem with renewed interest. He found that, previous to the encounter with Jupiter in 1886, the Brooks' comet was moving in an entirely different orbit to that which it now moves in. The periodic time in this former orbit was twenty-seven years, and its aphelion lay outside of Saturn's orbit, and the perihelion where the present aphelion is.

Mr. Chandler, in speaking of the motion of the comet before the disturbance of 1886, says: "Several months before reaching its perihelion, it passed, near the beginning of 1886, into the sphere of Jupiter's attraction, and was deflected into a hyperbolic path about the planet, remaining for more than eight months under its control—the disturbing action of the sun during most of the interval being insignificant. The eccentricity of the hyperbola was but sligthly in excess of unity, so that the comet narrowly escaped being drawn into a closed orbit as a satellite of Jupiter. A slight diminution of the initial velocity relatively to Jupiter would have thrown it into an elliptic orbit about the planet."

Mr. Chandler also says that, at the close approach to Jupiter in 1886, the comet passed a little outside of the orbit of the third satellite, and that it is not impossible that the

unequal attraction of Jupiter and his satellite system may have caused a disruption of the cometary matter such as would produce the companions that have been discovered attending it, and that these small bodies may owe their existence to the opposing attractions of Jupiter and his satellites, in 1886.

What have been the changes that this comet has undergone since 1770 through the repeated disturbances by Jupiter it is not possible to tell at present. However, the comet is now, at least, free from the disturbing action of that planet; but this will not continue indefinitely, as it will again encounter Jupiter in 1921, under nearly the same conditions as in 1886, and its orbit will again suffer a complete change, the comet, perhaps, once more being thrown into an orbit whose perihelion distance will be so great that it will again be lost to observers, with perhaps as long a period of invisibility as it has suffered since 1770, to reappear again some time in the future, through the attractions of Jupiter, if, indeed, it can maintain its integrity as a single body under the enormous stresses to which it has been, and may again be, subjected. However this may be, there is very little doubt that Mr. Chandler has been the first to point out one of the most remarkable of all cometary histories, and that his discovery is of the first importance.

E. E. BARNARD.

MT. HAMILTON, December 5, 1889.

The Lunar Crater and Rill—Hyginus.

I have asked Mr. Barnard to make positive enlargements on glass of one of our best moon negatives. A negative of August 14, 1888 (made by Mr. Burnham), has thus been enlarged two times, and shows the Moon, therefore, exactly as it would appear in the principal focus of a telescope 1140 inches, or 95 feet, long.* I find that I can use on this positive an eye-piece of one-inch equivalent focus as a magnifier. That is, it is practicable to examine the lunar surface under perfect conditions of definition and illumination, and under a magnifying power of more than 1100 diameters, or, as if viewed by the naked eye, at a distance of 217 miles or so.

* The focus of our photographic lens is 570.2 inches

This can be done whenever one pleases, and as long as one pleases.

As a test of the excellence of definition, I may mention a discovery which I have made on Mr. Barnard's enlargement It is well known that Mædler (and others) have mapped the walls of the *Hyginus* rill crossing the floor of the *Hyginus* crater So far as I know, this has only been once seen The observation is a delicate one, and could only be made when the sun is shining nearly in the direction of the preceding branch of the rill. The walls inside the crater are hardly more than 2000 *yards* apart, and their bright tops are not more than 200 to 220 *yards* wide Yet they are plainly and obviously visible in this enlargement

From this single example (among many others which could be given), it is possible to form a judgment of the results which a competent selenographer could draw from a series of our moon negatives. I have no hesitation in saying that a two or three years' study of such a series would produce greater results than all the previous work of observers in this line, great as these results have been Unfortunately, the limited force at the Lick Observatory will not permit us to undertake anything more than the production of the negatives themselves. By depositing sets of these at certain scientific centers, they will be sure, sooner or later, to be studied by competent observers.—*Abstract by* E. S HOLDEN

Contributions of Raphael and Albrecht Durer to Astronomy

It may not be known to all that Raphael's Madonna di Foligno has a special interest to astronomers. It is, I believe, the only painting of any note which commemorates an astronomical event This picture was painted by Raphael in 1511, and placed in the Church of Ara-Cœli, as a votive offering from Sigismund Conti, secretary to Pope Julius II., for his miraculous escape from death by an aerolite. The picture was removed to the Convent of Foligno in 1565 by a niece of Conti's, and was carried off by the French in 1792 It was returned in 1815 and is now in the Vatican. Such is a brief sketch of the wanderings of this exquisite painting. Its purely astronomical interest consists in the portrayal of

the fall of the aerolite itself, which occupies the centre of the picture. The drawing must have been made by Raphael from the personal account of Conti (who was living in 1512), and, therefore, it has even a certain scientific value.

It does not seem to be superfluous to call attention to this item of history, which lends a slight additional interest to one of the world's great pictures. I have presented a good photograph of this painting to the Astronomical Society's library.

The contribution of Albrecht Durer to astronomy is even more pronounced and permanent, though it is unknown, I believe, to all of his biographers.

Hipparchus (B. C. 127) and Ptolemy (A. D. 136) fixed the positions of stars by celestial latitudes and longitudes, and named the stars so fixed, by describing their situation in some constellation figure. The celestial globes of that day have all disappeared, and we have only a few Arabian copies of them, not more ancient than the XIIIth century, so that we may say that the original constellation-figures are entirely lost. The situations of the principal stars in each one of the forty-eight classic constellations are verbally described by Ptolemy. In Lalande's *Bibliographie Astronomique* we find that in A. D. 1515 Albrecht Durer published two star maps, one of each hemisphere, engraved on wood; in which the stars of Ptolemy were laid down by Heinfogel, a mathematician of Nuremberg. The stars themselves were connected by constellation-figures, drawn by Durer. These constellation-figures of Durer, with but few changes, have been copied by Bayer in his *Uranometria* (A. D. 1603); by Flamsteed in *Atlas Cœlestis* (1729); by Argelander in *Uranometria Nova* (1843), and by Heis in *Atlas Cœlestis Novus* (1872), and have thus become classic. It is a matter of congratulation that designs which are destined to be so permanent should have come down to us from the hands of so consummate a master. E. S. H.

Photographic Photometry.

Nature for October 10, 1889 (p. 584), has an abstract of a very important paper by Capt. Abney, F. R. S., on this subject, as follows:

"The author concludes, from his experiments, that the deposit of silver made by different intensities of light varies [in density] directly as the intensity of light acting—this, of course, within such limits that the reversal of the image is not commenced and that the film is not at any part exhausted of the silver salt which can be reduced."

Experiments by Mr. Leuschner on this same question are to be published. E. S. H

The Chief Discoverers of Comets.

Mr. W. F. Denning, in the *Observatory* for November, 1889, gives the following table, which is well worth reprinting. It has been completed to 1890.

Name of Discoverer	Period of Observations	No. of Comets discovered
Charles Messier	1760-1798	13
P. F. A. Mechain	1781-1799	8
Carolina Herschel	1786-1795	6
Jean Louis Pons	1802-1827	30
Padre di Vico	1844-1846	5
T. J. C. A. Brorsen	1846-1851	5
Wilhelm Klinkerfues	1853-1863	6
Carl Bruhns	1853-1864	7
Giovan B. Donati	1855-1864	5
F. Aug. T. Winnecke	1858-1881	13
Wilhelm E. Tempel	1859-1884	18
Lewis Swift	1862-1890	8
J. Coggia	1867-1877	7
Alphonse Borrelly	1871-1890	7
E. E. Barnard	1881-1890	13
W. R. Brooks	1883-1890	12

Mr. Brett on the Physical Condition of Mars.

Publications No. 5 of the Society (page 122), contains a résumé of a recent paper by M. Flammarion, on the physical condition of Mars. The fundamental asumption of that paper is that the dark markings on Mars represent areas of water. This assumption, while probable, is not yet proved.

A paper by Mr. John Brett, F. R. A. S., in the *Monthly Notices Royal Astronomical Society* for 1877 (vol. 38, p. 58), on the same subject, has not, it appears, received the attention it deserves.

It is worth while to summarize it here, in order to accent the wide difference of views held by observers of this planet, and because of its suggestiveness in many regards.

Mr. Brett's conclusions are based on his observations of

1877. He points out, first, that Mars does not show the same delicacy of detail (as Jupiter, for example), under like conditions; and he attributes to Mars an atmosphere of considerable opacity on this account. As the details of the planet's surface vanish before they reach the limb, while they are best seen at the center of the disc, and as the disc is brightest at the limb, the conclusion is that the markings themselves are situated below the surface of a tolerably dense atmosphere. The chief topographical features on Mars are permanent, and hence the body of the planet is solid. There are few or no clouds on Mars. This fact alone is fatal to the belief that the "land" and "water" on Mars act as on the earth. A whole opposition of Mars may pass and no changes of its own atmosphere be made out.

It is certain m spectroscopic observations) that watery vapor exists in the atmosphere of Mars. It does not necessarily follow that the vapor is anywhere condensed into visible clouds. If the polar caps are veritable "snow-caps," then clouds *must* exist in the atmosphere. Chilled water-vapor *must* produce clouds. As no (or few) evidences of clouds exist on the euqatorial regions of the planet, Mr. Brett's conclusion is that the so-called "snow-caps" cannot be snow-fields at all.

All the *dark* markings disappear before they reach the limb of the planet, while the "snow-caps" themselves are best seen at the limb, and often project far beyond it. This projection has been laid to irradiation. Mr. Brett thinks that the "snow-caps" are, in fact, clouds in the higher and colder regions of the atmosphere. The dark patches near the caps he supposes to be their shadows. He assumes that the regions near the poles are the only ones cool enough to condense the (invisible) water-vapor into visible clouds. Moreover, it follows that the surface of the planet in general is hot—hot enough to make the formation of clouds impossible; and it is likely, also, that the "seas" are not water.

Mr. Brett also points out that ordinary atmospheric absorption will not account for the fact that the central parts of Mars are red, while the limbs are "white" (lemon-yellow or yellowish white in the great telescope.) The nature of the absorption at the limb is one of the most difficult points to account for on a theory like that of M. Flammarion's,

previously cited Mr. Brett attempts no special explanation of the differences of color between the "seas" and the "continents,"—nor does he mention the "canals," of course

The above summary is given, as was said, simply to indicate the wide differences between plausible explanations of the phenomena observed on Mars. The fact that such differences of opinion are even possible indicates the unsatisfactory nature of our knowledge of this planet. E. S. H

A SIMPLE BREAK-CIRCUIT FOR CLOCKS.

WILLARD P GERRISH

For The Messenger

A break-circuit arrangement has been recently constructed and put into operation at Harvard College Observatory which works very satisfactorily. A small permanent horseshoe magnet was rigidly attached to the pendulum rod of a clock. A light brass contact spring, having at its free end a small soft iron armature, was fixed in front of the pendulum in such a position that the magnet would pass directly over it at the middle of each vibration. The contact spring was fitted with screws to regulate the amount of its motion. It was adjusted to rest with a slight pressure on a platinum tip at the end of one of these screws through which the circuit was completed. At each beat of the pendulum the spring is lifted by a slight amount, breaking the circuit, which is immediately closed again after the pendulum and magnet have passed. As the magnet never comes into contact with the armature, friction is entirely avoided, the only work done being that required to lift the spring. Since the spring is very light a minimum amount of energy is absorbed in its operation. This form of break-circuit is easily constructed and can be applied in a few minutes to any clock It will make or break the circuit with equal facility, as the contact spring strikes a fixed stop in rising as well as in falling, and in so doing in no way affects the pendulum Although the device may have been tried before, it is not in general use and is worthy of the attention of astronomers on account of its cheapness and simplicity. It has been in

use during the past two months for giving the signals which control the motion of the Draper eight-inch photographic telescope.

February 12, 1890.

COMET 1889 V (BROOKS, JULY 6).

DR. H. C. WILSON.

For The Messenger.

This comet promises to be one of the most interesting ones yet discovered, not because of its brilliancy, but because of its probable identity with the lost Lexell comet of 1770 and of the interesting and exceedingly difficult problem which it offers in the calculations of its perturbations and the tracing of its path during the period of 119 years during which it has been lost to sight. The comet is at present moving in a short ellipse having a period of a little over seven years, but in an article published in the *Astronomical Journal*, No. 204, Mr. S. C. Chandler pointed out the fact that in 1886 the comet must have passed very close to the planet Jupiter, in fact through the system of his satellites, and its orbit must then have been radically changed. In a later paper (*Astr. Jour.* No. 205), Mr. Chandler gives the results of a rough calculation of the principal perturbations by Jupiter, that is, from Jan. 24 to Sept. 14, 1886, and attempts to trace the course of the comet backward from that time, reaching some very remarkable conclusions. He finds that the encounter with Jupiter in 1886 effected a complete transformation of the comet's orbit. Instead of the present small seven years' ellipse, it was previously moving in a large one of twenty-seven years' period, whose aphelion lay outside of Saturn's orbit, and whose perihelion was almost exactly at the present aphelion distance. The directions of the lines of the apsides and nodes were reversed and turned through an angle of about twenty degrees. The plane of the orbit was also tilted about fourteen degrees.

A comparison of the following sets of elements will show the radical character of the changes:

	Before 1886.		After 1886.	
T	1886 Nov. 28 779 Gr. M. T.		1889 Sept. 30.0119 Gr. M. T.	
$\pi =$	203° 03′ 7	1890 0	1° 26′ 17″.3	1890.0
$\Omega =$	179 13 4		17 58 45 .3	
i	7 43 8		6 04 10 .5	
e	0 3947		0.470704	
$a =$	8.9896		3.684682	
q	5 4411		1.950229	
Period =	26.95 years.		7.0730 years	

Several months before reaching perihelion the comet passed, near the beginning of 1886, into the sphere of Jupiter's attraction, and was deflected into a hyperbolic path about that planet, remaining for more than eight months under its control; the disturbing influence of the sun during most of the interval being insignificant. The eccentricity of the hyperbola was but little over unity, the comet having narrowly escaped being drawn permanently into Jupiter's satellite system. At the point of nearest approach to Jupiter May 20, 1886, the comet was distant only nine diameter's of the planet from his center, almost as near as the third satellite. It is not impossible that the comet may have come into such a position with reference to the satellites and planet, that their unequal attraction upon different parts of its diffuse mass may have tended to disruption, and have brought about the separation of portions such as were actually observed during its present apparition.

Professor Bredichin has added almost certainty to this surmise of Mr. Chandler's by publishing, in *Astronomische Nachrichten* No. 2949, the results of some calculations which he has made upon the orbits of the companion comets, which were detected by Mr. Barnard in the early part of August, 1889, and were observed until about the end of October. Taking Mr. Chandler's first set of elliptic elements (*Astr. Jour.* No 204) for the orbit of the principal mass of the comet, designated *A*, Professor Bredichin has computed, by a differential method, the orbits of the masses *C* and *E*, and finds that they intersect the orbit of *A* at almost the same point, and that point is about 1° beyond the present aphelion point, almost exactly where the comet was nearest to Jupiter. The orbit of the mass *B* is between the orbits of *A* and *C*, and that of *D* between those of *C* and *E*.

Tracing backward the course of the comet, with the elements of the 27 year orbit, Mr Chandler found that the

comet would not have approached near enough to any planet to have its path greatly changed until 1779. In that year, however, the comet must have come so near to Jupiter as to pass under its control and experience a radical change of its orbit at the point of longitude where Lexell's comet underwent its notable disturbance in that year. This coincidence, in time and place, of approach to Jupiter is very strong presumptive evidence of the identity of the two comets. It is certainly very striking if it be merely an accidental coincidence. Moreover, there is a strong resemblance between some of the elements of Comet 1889 V, before 1886, and those of Lexell's comet after 1779, as shown in the following table, in which Mr. Chandler's elements are carried back to 1770.

	Lexell's Comet after 1779.			Comet 1889 V before 1886.
	Burckhardt.	Le Verrier.		Chandler.
		$\mu=-0.10$	$\mu=+0.35$	
π	301° 19′	110° 00′	258° 40′	201°24′
☊	183 15	178 06	175 27	177 34
i	14 42	18 50	11 27	7 43
e	0.478	0.535	0.533	0.395
a	6.388	9.000	9.000	8.990

The two sets of elements by Le Verrier were selected from a large number of possible sets obtained by varying the indeterminate quantity μ. These both correspond to a period of about twenty-seven years. Le Verrier found that the observations of 1770 could be represented equally well by a number of orbits, differing slightly, it is true, but enough to make an enormous difference when the perturbations by Jupiter in 1779 were to be calculated. He therefore gave up the attempt to calculate definitive elements of the comet's new orbit, but introduced into the expression for each an indeterminate quantity μ, by the variation of which elements could be obtained to suit different conditions. He has given a table of such elements, corresponding to different values of , in which it may be seen that the values of ☊ and i vary slightly within very narrow limits while the other elements have a very wide range of variation. The agreement of the ☊ of the comet of 1889 with that of Lexell's is very striking and the inclination also agrees within reasonable limits. The semi-major axis a also agrees with the two selected from Le Verrier's table, but these depend upon the assumption of the 27 year period. The fact that four periods of 26.95

years are very nearly equal to the interval 107 years between the approaches of the two comets to Jupiter in 1779 and 1886 would seem to attest the substantial correctness of the period.

There is, however, room to doubt, as Mr. Chandler himself admits, whether the method which he pursued is adequate to the attainment of such precision in the dimensions of the ellipse previous to 1886, as the above implies. It is quite possible that the period derived that way may be in error by several years and even that the comet may have made only three revolutions in the 107 years. In this case Mr. Chandler points out the fact that the comet would have approached Jupiter again in 1815 and 1850, suffering enormous perturbations, the effect of which it would be impossible to calculate The probability that this may have been the case is heightened by the fact that the very elements of Lexell's comet which Mr. Chandler selects give periods of 33 years and slightly different ones would give 35 and 36 years.

In the *Bulletin Astronomique*, tome VI, Nov. 1889, Mr. Schulhof has discussed the possibility of identity of several pairs of periodic comets by means of a criterion which has been expressed in a neat mathematical formula by M Tisserand. This criterion depends upon the fact that a body revolving about another as a center has the same velocity for equal radius vectors. A comet under the influence of strong perturbations by a planet revolves for the time about the planet as a center, and, therefore, has equal velocities at the two points of entering and leaving the sphere of influence of the planet, the one point being in the old, the other in the new orbit. M. Tisserand expresses this relation very approximately by the formula,

$$\frac{1}{a_{,}} - \frac{1}{a_{,,}} = \frac{2\sqrt{A}}{R^{3}} \left(\sqrt{p_{,,}} \cos i_{,,} - \sqrt{p_{,}} \cos i_{,}\right),$$

in which $a_{,}$, $a_{,,}$, $p_{,}$, $p_{,,}$, $i_{,}$, $i_{,,}$ are the semi-major axes, parameter and inclinations of the old and new orbits of the comet, and A and R are the semi-major axis and radius vector of the planet's orbit at the point of nearest approach. This formula may be separated in two equal parts of the form

$$n = \frac{1}{a} + \frac{2\sqrt{A}}{R^2}\sqrt{p}\cos i,$$

which are convenient in comparing comets which exhibit signs of identity. In the following table the values of n as computed by Mr. Schulhof are given together with the elements of the 21 known periodic comets, and their longitudes at the point of proximity to Jupiter:

Name.	n	π	☊	i	e	a	l
1. Denning 1881	0.412	19°	66°	7°	0.83	4.28	223°
2. Piggott 1783	0.473	50	56	45	0.55	3.26	233
3. Brorsen 1846	0.476	116	103	31	0.79	3.14	283
4. Finlay 1886	0.843	8	52	3	0.72	3.54	205
5. Lexell 1770	0.485	356	132	2	0.79	3.16	184
6. Biela 1772	0.486	110	257	17	0.72	3.58	268
7. Helfenzrieder 1766	0.493	251	74	8	0.86	2.93	80
8. Wolf 1884	0.496	19	206	25	0.56	3.58	210
9. D'Arrest 1851	0.503	323	148	14	0.66	3.44	153
10. Faye 1843	0.507	50	209	11	0.56	3.81	209
11. Winnecke 1858	0.508	276	114	11	0.75	3.14	113
12. Tuttle 1858	0.527	201	175	20	0.67	3.52	0
13. Brooks 1889	0.530	2	18	6	0.47	3.67	185
14. Tempel-Swift 1869	0.534	43	297	5	0.66	3.11	223
15. De Vico 1844	0.537	343	64	3	0.62	3.10	162
16. Brooks 1886	0.553	230	52	13	0.61	3.41	53
17. Tempel 1873	0.562	306	121	13	0.55	3.00	125
18. Blanpain 1819	0.566	67	77	9	0.69	2.85	247
19. Barnard 1884	0.566	306	5	5	0.57	3.08	126
20. Tempel 1867	0.590	236	101	6	0.51	3.19	60
21. Encke 1795	0.591	157	335	14	0.85	2.21	335

It will be seen from this table that the quantity n does not vary very widely for all the twenty-one comets. For a single comet the perturbations by a single planet can produce only a slight variation. Schulhof puts the limit of this variation at 0.01. This criterion then would seem to exclude the possibility of the identity of the two comets now under consideration, for the difference between the values of n is 0.045.

But there is an exceptional case in which n is not constant, that is, when the comet's path is disturbed by a second planet, and it seems probable that this may have been the case with Lexell's comet. In a later paper (*Bull. Astr.* Dec. 1889) Mr. Schulhof, after seeing Mr. Chandler's results, shows that the comet may have approached near to Saturn between 1779 and 1886, so that his action has modified the value of n, calculated on the hypothesis that Jupiter was the only disturbing body. This indispensable condition of a strong perturbation by Saturn gives a means of determining ap-

proximately the period of revolution which the comet must have had, on the supposition of identity, after 1779 and before 1886. An examination of Le Verrier's table of elements showed that the comet after leaving Jupiter in 1779 would approach quite near to Saturn if the value of μ were −0.08 or +0.32. The two corresponding sets of elements are given below with those obtained by Mr. Chandler:

μ	T	π	☊	i	e	a	P
−0.08	1812.35	120.5	178.1	18.7	0.576	10.55	34.27y
+0.32	1781.06	250.0	175.7	11.9	0.615	10.70	35.00
	1886.91	203.1	179.2	7.7	0.395	8.99	26.95

On the first supposition the comet was at its shortest distance from Saturn's orbit in heliocentric longitude 6 about 1808.0, 1842.2 and 1876.5; and on the second supposition in longitude 8 about 1785.3, 1820.3 and 1855.3; Saturn being at the same points about 1790.9, 1820.4, 1849.9 and 1879.4. The close coincidence of the dates 1820.3 and 1820.4 points to the second set of elements as the more probable, but this would make the period almost uniform from 1779 to 1886, while in order to reconcile the values of n the period is required to be greater before 1886. Mr. Schulhof finds the criterion to be best satisfied by supposing the period to have been about 32 years from 1779 to 1849, at which epoch the comet passed near Saturn and its period was increased to about 42 years. This would avoid bringing the comet near to Jupiter in 1815 and 1850 or at any time between 1779 and 1886.

For the next four periods of about seven years the comet will be free from serious perturbations, appearing in 1896, 1903, 1910 and 1917 under favorable conditions for observation, but in 1921 it will again enter into the sphere of Jupiter's activity and undergo another violent transmutation.

Altogether the investigations of Messrs Chandler, Schulhof and Bredichin are exceedingly interesting although the results are as yet very uncertain. The problem is one that will tax to the utmost the powers of mathematical research, and is of the greatest importance in its bearing upon our knowledge of the constitution and origin of these erratic members of the solar system. What a grand achievement if the computer shall succeed in following, with reasonable certainty, the wanderings of this wisp of nebulosity, as it is whisked about from one ellipse to another by the giant planets Jupiter and Saturn!

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at superior conjunction on the morning of April 9. During the first days of March it may be visible to the naked eye a little before sunrise. The best observations of this planet, however, have been made when the sun was above the horizon and the planet at as great an altitude as possible. It was by following the planet through the day, even when it was more distant than the sun, that Professor Schiaparelli made his brilliant discovery of the rotation period of Mercury, which we referred to last month. It is only when the phase of Mercury is nearly full, and therefore when the planet is on the farther side of its orbit, its disk being then only 5″ in diameter, that the general configuration of its surface markings can be seen.

If it be true that the rotation period of Mercury is the same as that of its revolution around the sun, and this does not seem to be at all unreasonable, what strange conditions of affairs must exist upon that planet! One hemisphere in perpetual day, the other in everlasting night! One in perpetual heat, the other in intense and never ceasing cold! At one point upon the sunward hemisphere the sun is in the zenith, oscillating 23° 41′ alternately to the east and west, at others alternately above and below the same point of the horizon, during the period of 88 of our days. Many interesting, although of course useless, questions present themselves to one's mind in contemplating these conditions. Are there living intelligent beings there? On what part of the globe do they live? How do they measure time? etc.

Venus has just passed superior conjunction, becoming now "evening star." In the latter part of March it will be visible to the eye in the west after sunset but so low that telescopic observations will be unsatisfactory. The success, however, of Professor Schiaparelli in seeing the markings on Mercury in full sunlight should encourage observers to study Venus in the same way. Its position this month will be very favorable for study of Venus in that way, as the phase is almost full and the declination will permit the planet to reach an altitude of from 45° to 50°.

Mars will be in Scorpio, during this month, just a little north of the red star Antares. The two ruddy objects, visible in the morning in the south, will be nearly alike in brightness and color.

Jupiter is in the constellation of Capricorn, and may be found in the southeast in the morning, it being brighter than any of the stars in that part of the sky.

Saturn may be easily found in the evening. Looking toward the east at eight o'clock one sees, about half way to the zenith, two bright stars and a group of fainter ones in the form of a sickle. The brighter of the two stars is Saturn, whose yellow light also distinguishes him from the other, Regulus, whose light is bluish white. We have had several good views of Saturn lately with the eight-inch refractor. The white equatorial belt is conspicuous. The divisions between the rings are becoming difficult to see with small telescopes, because the rings are turned so nearly edgewise to us.

Uranus will be at opposition to the sun April 14, and so can be well seen in the evening.

Neptune is still visible in the evening, between the Hyades and Pleiades. Our class in practical astronomy on one evening recently looked up this planet and found two objects in the field of view, of almost exactly the same brightness and color. The only way to distinguish between the planet and star, as the definition was somewhat poor, was by the difference in intensity of the light of the two objects, the light of Neptune being duller than that of the star.

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
			MERCURY.		
Mar. 26	23 37.5	− 4 48	5 37 A.M.	11 21.1 A.M.	5 07 P.M.
April 5	0 46.4	+ 3 33	5 33 "	11 50.5 "	6 08 "
15	2 02.5	+12 47	5 32 "	12 27.1 P.M.	7 22 "
			VENUS.		
Mar. 26	0 57.2	+ 4 56	6 18 A.M.	12 40.5 P.M.	7 03 P.M.
April 5	1 43.1	+ 9 51	6 04 "	12 47.1 "	7 30 "
15	2 30.2	+14 23	5 53 "	12 54.6 "	7 56 "
			MARS.		
Mar. 26	16 30.8	−21 03	11 36 P.M.	4 11.7 A.M.	8 47 A.M.
April 5	16 40.5	−21 37	11 09 "	3 41.9 "	8 14 "
15	16 46.1	−22 06	10 38 "	3 08.2 "	7 38 "
			JUPITER.		
Mar. 26	20 34.1	−19 07	3 34 A.M.	8 18.3 A.M.	1 03 P.M.
April 5	20 40.7	−18 44	3 00 "	7 45.8 "	12 32 "
15	20 46.5	−18 24	2 25 "	7 12.0 "	11 59 A.M.
			SATURN.		
Mar. 26	10 02.9	+13 49	2 45 P.M.	9 44.7 P.M.	4 44 A.M.
April 5	10 01.1	+13 58	2 04 "	9 03.7 "	4 04 "
15	9 59.8	+14 04	1 22 "	8 23.1 "	3 24 "
			URANUS.		
Mar. 26	13 35.3	− 9 17	7 50 P.M.	1 16.5 A.M.	6 43 A.M.
April 5	13 33.7	− 9 08	7 09 "	12 35.7 "	6 03 "
15	13 32.1	− 8 58	6 27 "	11 54.7 P.M.	5 22 "
			NEPTUNE.		
Mar. 26	4 02.2	+19 03	8 22 A.M.	3 45.1 P.M.	11 08 P.M.
April 5	4 03.2	+19 07	7 43 "	3 06.8 "	10 30 "
15	4 04.5	+19 11	7 65 "	2 28.7 "	9 52 "
			THE SUN.		
Mar. 26	0 22.2	+ 2 24	5 52 A.M.	12 05.7 P.M.	6 20 P.M.
April 5	0 58.6	+ 6 16	5 33 "	12 02.6 "	6 32 "
15	1 35.3	+ 9 56	5 16 "	11 59.9 A.M.	6 44 "
			THE MOON.		
Mar. 21	1 01.1	+ 0 46	6 50 P.M.	12 59.0 P.M.	7 17 P.M.
26	5 18.6	+22 29	9 13 A.M.	5 01.3 "	12 56 A.M.
31	9 42.9	+18 05	1 28 P.M.	9 05.2 "	4 32 "
April 5	13 47.8	− 6 30	6 55 "	12 49.7 A.M.	6 34 "
10	17 34.1	−23 09	11 45 "	4 19.8 "	8 52 "
15	22 44.4	−13 12	3 57 A.M.	9 09.6 "	2 32 P.M.

[The above tables give local times for the Central Meridian and latitu +44° 28′.]

Ephemerides of Saturn's Satellites.

[Computed by A. Marth, Monthly Notices R. A. S., vol. L., No. 1, p. 56.]

Date	Time	Phenomenon
Mar. 15	12.5 p. m.	En. s.
	3.7 p. m.	Mi n
	6.6 p. m.	Te. n.
	8.2 p. m.	Di s
16	1.5 a. m.	Rh. s.
	7.5 a. m.	Tit s. 37"
	2.3 p. m.	Mi n
	5.8 p. m.	Te. s.
	9.4 p. m.	En. s
17	4.6 a. m.	Rh e
	5.0 a. m.	Di n
	12.9 p. m.	Mi n
	1.9 p. m.	En n
	3.9 p. m.	Te n
18	7.7 a. m.	Rh n
	1.9 p. m.	Di s.
	2.6 p. m.	Te. s.
	10.7 p. m.	En n
	10.8 p. m.	Mi s
19	10.8 a. m.	Rh. w
	1.2 p. m.	Te. n
	3.2 p. m.	En s.
	9.5 p. m.	Mi. s.
	10.7 p. m.	Di n.
20	11.8 a. m.	Te. s.
	1.9 p. m.	Rh s.
	5.1 p. m.	Mi s.
21	12.1 a. m.	En. s.
	7.5 a. m.	Di. s.
	10.5 a. m.	Te. n
	4.5 p. m.	En. n
	5.0 p. m.	Rh e.
	6.7 p. m.	Mi s.
22	9.1 a. m.	Te. s.
	4.4 p. m.	Di n
	5.8 p. m.	Mi s.
	8.1 p. m.	Rh. n
23	7.8 a. m.	Te. n
	3.9 p. m.	Mi s
	5.8 p. m.	En s.
	11.1 p. m.	Rh. w
24	12.9 a. m.	Tit n 37"
	1.2 a. m.	Di s.
	6.4 a. m.	Te. s.
	2.5 p. m.	Mi. s
25	2.2 a. m.	Rh s
	6.1 a. m.	Te. n
	10.0 a. m.	Di n
	1.2 p. m.	Mi s.
	7.1 p. m.	En. n
26	3.7 a. m.	Te. s.
	5.3 a. m.	Rh. e
	11.6 a. m.	En s.
Mar. 26	11.8 a. m.	Mi s.
	6.9 p. m.	Di. s.
27	2.4 a. m.	Te n
	8.4 a. m.	Rh n
	8.5 p. m.	En s.
	9.7 p. m.	Mi n
28	1.0 a. m.	Te s
	3.7 a. m.	Di n
	11.5 a. m.	Rh w
	12.9 p. m.	En n.
	8.3 p. m.	Mi. n
	11.7 p. m.	Te n
29	12.5 p. m.	Di s.
	2.6 p. m.	Rh s.
	6.9 p. m.	Mi n
	9.8 p. m.	En n
	10.3 p. m.	Te s.
30	2.2 p. m.	En s.
	5.5 p. m.	Mi n
	5.7 p. m.	Rh e
	9.0 p. m.	Te n
	9.4 p. m.	Di n.
31	4.2 p. m.	Mi n
	7.6 p. m.	Te s.
	8.8 p. m.	Rh n.
April 1	5.6 a. m.	Tit s 38"
	6.6 a. m.	Di s
	6.3 p. m.	Te n
	11.9 p. m.	Rh w
2	3.0 p. m.	Di. n
	4.9 p. m.	Te. s
3	3.0 a. m.	Rh s.
	3.6 p. m.	Te. n
	11.9 p. m.	Di s.
4	6.1 a. m.	Rh e.
	2.2 p. m.	Te. s.
5	8.7 a. m.	Di n
	9.2 a. m.	Rh n
	12.9 p. m.	Te. n
	6.2 p. m.	En n.
	8.6 p. m.	Mi s.
6	11.5 a. m.	Te. s.
	12.3 p. m.	Rh. w
	5.5 p. m.	Di s.
	7.2 p. m.	Mi. s.
7	10.2 a. m.	Te. n
	3.3 p. m.	Rh s
	6.8 p. m.	Mi s.
	7.5 p. m.	En s
8	2.4 a. m.	Di n
	8.8 a. m.	Te. s.
	12.0 m.	En n
April 8	1.9 p. m.	Di c Jap. 3"
	4.4 p. m.	Mi. s.
	6.4 p. m.	Rh. e.
	10.9 p. m.	Tit n 37"
9	6.7 a. m.	Mi c prec. end of ring 4"
	6.9 a. m.	Mi c Jap. 6"
	7.5 a. m.	Te n.
	7.7 a. m.	Jap. c prec. end of ring 4" n.
	10.7 a. m.	Jap occulted by ring. Disapp. 3" n.
	11.2 a. m.	Di. s
	3.0 p. m.	Mi. s.
	8.0 p. m.	En n.
	9.5 p. m.	Rh n
10	12.8 a. m.	Jap* emerging from behind the ball in the space within the crape ring
	5.5 a. m.	Jap reapp. from occultation by the ring 2" e.
	6.1 a. m.	Te s.
	7.5 a. m.	Jap. c foll. end of ring 3" s.
	10.6 a. m.	Te. c. Jap. 4".
	1.3 p. m.	En s.
	1.6 p. m.	Mi. s.
	8.1 p. m.	Di n
11	12.6 a. m.	Rh. w
	4.8 a. m.	Te n
	12.3 p. m.	Mi s.
	10.2 p. m.	En s
12	3.4 a. m.	Te. s
	3.7 a. m.	Rh s.
	4.9 a. m.	Di s.
	2.6 p. m.	En n
	10.2 p. m.	Mi n
13	2.1 a. m.	Te n
	6.8 a. m.	Rh e.
	1.7 p. m.	Di n.
	8.8 p. m.	Mi n
	11.5 p. m.	En. n
14	12.7 a. m.	Te. s
	9.9 a. m.	Rh n.
	3.0 p. m.	En s.
	7.4 p. m.	Mi n
	10.6 p. m.	Di s
	11.4 p. m.	Te. n

En. = Enceladus, Di. = Dione; Jap. = Japetus; Mi. = Mimas; Rh. = Rhea. Te = Tethys; Tit. = Titan; c = conjunction; e. = eastern elongation, w = western elongation, n = north of center of planet s. = south of center of planet. The conjunctions of the three innermost planets with the ends of the ring take place in the case of Mimas about 2.6h, Enceladus, 3.2h, Tethys, 3.5h before and after the predicted conjunctions with the center, which are not observable.

Occultations Visible at Washington.

Date.	Star's Name	Magnitude.	IMMERSION Wash. Mean T. h m	IMMERSION Angle f'm N. P't °	EMERSION Wash. Mean T. h m	EMERSION Angle f'm N. P't °	Duration h m
Mar. 29	μ^1 Cancri	6½	8 05	90	9 32	301	1 26
Apr. 5	88 Virginis	6½	9 30	103	10 40	324	1 09
5	B.A.C. 4647	6½	14 38	125	15 51	301	1 13
7	ζ^3 Librae	6	9 05	123	10 02	289	0 58
7	ζ^4 Librae	5½	10 12	119	11 15	295	1 03
13	$\varkappa$ Capricorni	5	15 16	45	16 11	291	0 55

Minima of Variable Stars of the Algol Type.

	R. A. h m s	Decl. ° ′	Range of Magnitude.	Period. d h m	Approx. Central Times of Minima.
U Cephei	0 52 32	+ 81 17	7.1 to 9.2	2 11 50	Mar. 20, 11^h^ P.M.; 25, 11^h^ P.M.; 30, 11^h^ P.M.; April 4, 10^h^ P.M.; 9, 10^h^ P.M.; 14, 10^h^ P.M.
Algol	3 01 01	+ 40 32	2.3 to 3.5	2 20 49	Mar. 19, 5^h^ A.M.; 22, 2^h^ A.M.; 24, 11^h^ P.M.; 26, 8^h^ P.M.
λ Tauri	3 54 35	+ 12 11	3.4 to 4.2	3 22 52	Mar. 19, 7^h^ P.M.; 23, 6^h^ P.M..
R Canis Maj.	7 14 30	− 16 11	5.9 to 6.7	1 03 16	Mar. 23, 9^h^ P.M.; 31, 8^h^ P.M.; April 1, 11^h^ P.M.; 9, 10^h^ P.M.
S Cancri	8 37 39	+ 19 26	8.2 to 9.8	9 11 38	Mar. 25, 10^h^ P.M.; April 13, 9^h^ P.M.
δ Libræ	14 55 06	− 8 05	5.2 to 6.2	2 07 51	Mar. 16, 10^h^ P.M.; 23, 10^h^ P.M.; 30, 10^h^ P.M.; Apr. 6, 9^h^ P.M.; 13, 9^h^ P.M.
U Coronæ	15 13 43	+ 32 03	7.5 to 8.9	3 10 51	Mar. 22, 1^h^ A.M.; 28, 11^h^ P.M.
U Ophiuchi	17 10 56	+ 1 20	6.0 to 6.7	0 20 08	Mar. 23, 1^h^ A.M.; 28, 2^h^ A.M.; April 2, 3^h^ A.M.; 7, 4^h^ A.M.; 12, 5^h^ A.M.

Phases of the Moon.

			Central Time. d	h	m	
New Moon	1890	March	20	3	01	P. M.
First Quarter	"	"	28	3	33	A. M.
Full Moon	"	April	5	3	24	A. M.
Last Quarter	"	"	12	4	53	A. M.
Perigee	"	March	17	8	54	P. M.
Apogee	"	"	29	3	42	P. M.
Perigee	"	April	13	11	12	A. M.

COMET NOTES.

Transit of Comet d, 1889, (Brooks, July 6,) over a star. On the evening of January 17, Mr. O. C. Wendell made his customary examination of the physical peculiarities of this comet previous to taking transits. This was done not only from the fact that this body has sent off several companion comets already, but also because on the two nights previous, a suspicion had been entertained of a subdivision in the nucleus. This latter appearance was probably due to bad seeing, as was thought possible at the time. On the night in question, under a careful scrutiny, no apparent subdivision was seen at the first, but, on the other hand, it was remarked that the comet's nucleus was unusually sharp and well defined. Transits were accordingly taken, but before finishing them there be-

gan to be the appearance of two nuclei, one sharp and stellar, the other having the more usual cometary appearance. Then it at once became evident that the comet had passed centrally over a star, which had accordingly been taken in transit. As the comet moved away, it was estimated that the increase in the star's brightness was possibly two-tenths of a magnitude. In other words, the comet had passed centrally over a 10.7 magnitude star with scarcely any diminution of its light.

Comet 1886 VII (Finlay). Mr. L. Schulhof at Paris is about to compute definitive elements of this comet and desires all unpublished observations to be communicated as soon as possible.

Comet 1889 I (Barnard, Sept. 2, 1888). This comet was observed from Sept. 4, 1888, to Feb. 17, 1889, and from May 22 to Oct. 22, 1889, and perhaps later observations have not been published. Dr. A. Berberich (*Astr. Nach.* No. 2946) has computed very accurate elements of its orbit from all the published observations. Fifteen normal places were formed, which are all represented within their possible errors by the new elements.

$$T = 1889 \text{ Jan. } 31.209083 \text{ Berlin mean time.}$$

$$\left.\begin{aligned} \omega &= 340^\circ\ 27'\ 39.74'' \\ \Omega &= 357\ \ 25\ \ 14.93 \\ i &= 116\ \ 22\ \ 12.83 \end{aligned}\right\} 1889.0$$

$$\log q = 0.2588515 \qquad q = 1.814894$$

$$e = 1.0010863$$

It will be seen from the value of e that the orbit of this comet is an hyperbola. Dr. Berberich thinks he has found the cause of deviation from a parabolic path in a near approach of the comet to the orbit of Uranus in 1882. The angular distance between the comet and planet as seen from the sun was 10° and the actual distance between them about three times the earth's distance from the sun. The perturbation then produced by the planet upon the comet's motion was in the right direction and, considering the long duration of its influence, was probably sufficient to change the orbit from a parabola to its present form. The comet is now moving almost directly toward Jupiter, its distance at the beginning of this year being about the same as the earth's distance from the sun, so that further perturbations are likely again to change the form of the orbit. It is possible that the comet will still be visible for a few months with the aid of large telescopes, the theoretical brightness being about 0.09 of that at the time of discovery Sept. 2, 1888. The following ephemeris by Dr. Berberich will enable observers to find the place of the comet and test the powers of their telescopes and eye-sight in this direction. The only chance to see it will be about two hours before sunrise.

1890 Berlin midnight	α app. h m s	δ app. ° ′	log r	log Δ
March 8	18 55 00	−10 06.7	0.6832	0.7122
12	54 43	− 9 56.1		
16	54 14	− 9 45.4	0.6895	0.7066
20	53 33	− 9 34.7		
24	52 38	− 9 23.9	0.6956	0.7004
28	51 29	− 9 13.1		
April 1	50 05	− 9 02.4	0.7016	0.6938
5	48 28	− 8 51.7		
9	46 36	− 8 41.2	0.7076	0.6871
13	44 28	− 8 30.9		

Sunspots during the past month have been very few and small. The following is the record of observations at Carleton College Observatory from Dec. 18, 1889, to Feb. 20, 1890. The instrument employed is the 8-inch refractor, full aperture, the image of the sun being projected through a comet eye-piece upon a screen. The diameter of the image is usually about 15 inches and the spots which are distinctly seen are counted. These observations are made by Miss C. R. Willard and H. C. Wilson.

Date (Civil) 1889.	Central Time.	No. groups	No. spots...	Faculæ......	Observer....	Remarks.
Dec. 18	12h00m	1	4	0	H.C.W.	
20	12 20	2	15	10	"	Both groups in north latitude.
25	9 45	1	10	0	"	One large spot followed by small ones in S. latitude.
26	12 30	1	18	1	"	
27	2 30	2	25	12	"	New large spot surrounded by brilliant faculæ near east limb. Fine aurora last night from 9h to 3h.
30	12 30	2	4	15	"	Group near west limb surrounded by brilliant facula. Spot to east of center has two umbræ.
1890.						
Jan. 2	12 00	1	1	0	"	
7	3 15	4	12	6 gr.	"	Two groups of spots north and two south of equator.
9	10 15	1	2	2	"	
10	2 45	0	0	3 gr.	C.R.W.	Large group of faculæ near E. limb.
13	0 0	0	0	1 gr.	"	
17	12 45	1	3	1 gr.	"	Large group of faculæ 1-5 way across disk. Faint aurora at 10 P. M.
20	12 45	1	6	1 gr.	H.C.W.	Two large spots with large area of faculæ.
21	2 30	0	0	0	C.R.W.	Definition poor.
23	2 30	0	0	0	"	
25	12 40	0	0	1 gr.	H.C.W.	Faculæ near S. W. limb.
27	2 05	0	0	"	C.R.W.	" " " " .
30	9 45	0	0	0	"	
31	11 15	1	4	0	H.C.W.	Group in north latitude about ⅓ way across.
Feb. 1	12 50	1	4	1	C.R.W.	
5	12 25	0	0	1 gr.	"	
6	9 30	0	0	1 gr.	"	
7	9 30	0	0	2 gr.	H.C.W.	
8	12 30	0	0	1gr. E	C.R.W.	
11	4 45	0	0	3	H.C.W.	Aurora, faint low arch, noticed from 8 to 10 P. M.
13	4 30	0	0	1 NE	"	
14	12 15	0	0	1gr. SW	"	
15	12 30	0	0	"	C.R.W.	
18	12 30	0	0	2 gr. W	"	
20	12 30	1	1	1 gr.	"	Faint spot near center.

Knowledge for February 1890, contains a beautiful photo-engraving of a remarkable sunspot, photographed by Dr. Jannsen at Meudon, France. This photograph shows a great deal of detail in the penumbra of the spot and in the granulation of the general surface of the sun. But we can hardly subscribe to Mr. Ranyard's astonishing statement that "Our en-

larged copy shows as much as can be seen under the best conditions with the eye at the telescope; and the negative from which it is made shows still more." The copy before us, which seems to be a very perfect one, certainly shows nowhere near what can be seen with our eight-inch refractor under fair conditions, even with the aperture reduced to two inches.

L'Astronomie, Feb. 1890, contains an interesting note in regard to the large spot which appeared upon the sun in June 1889. This spot was observed during three rotations of the sun in June, July and August, disappearing August 20, reduced to a point, before it reached the west limb. On June 28 when the spot was for the first time at the west limb of the sun, Mr. Ricco at Palermo noticed a curious irregularity of the edge of the solar disk, a depression at the spot and one or two elevations on either side. This same irregularity is shown upon the photographs taken the same day at Potsdam. Mr. Ricco determined on each day of observation the exact position of the spot upon the solar disk. When these positions are plotted in latitude and longitude they indicate a curiously irregular course of proper motion of the spot. We hope to give an engraving of this sunspot track in our next number. H. C. W.

Smith Observatory Observations. The following observations of the sun's surface were made with the Brashear Helioscope attached to the 9½ inch equatorial of Smith Observatory. A power of 98 was most commonly used in connection with filar micrometer which Mr. Brashear fitted to the Helioscope.

1890.	90m M.T.	Groups.	Spots.	Remarks.
Jan. 20	2	1	4	Seeing fair.
21	1.50	1	4	Seeing poor. Little change: faculæ bright.
23	2	0	0	Seeing very poor. Gran. structure difficult.
24	1.50	0	0	Seeing fair. Faint faculæ near S. E. limb.
27	2	0	0	Seeing good. Gran. st. sharp; no faculæ.
28	2.30	0	0	Seeing fair. No faculæ.
29	2.20	0	0	Seeing fine. Willow leaves visible to limb.*
30	3.50	1	3	Seeing fair. Small and poor. N. lat.
31	2.15	2	5	Seeing fair. Single group div. into two.

Beloit, Wis., Feb. 8, 1890. CHAS. A. BACON.

Smith's Planetary Almanac for 1890 is published by Walter H. Smith, 31 Arcade St., Montreal, Canada. It contains considerable about the planets for each month. Its mailing price is twelve cents per copy.

The Hartford Fire-Ball. December 24 we wrote to Professor R. B. Riggs, of Hartford, Connecticut, concerning the so-called fire-ball which fell in the streets of that city, Dec. 10, as described in the January issue of this journal (p. 40), and asked of him specific information concerning it. In his reply of January 21, he states that he had succeeded in getting a fragment of two or three grams of it, and made a partial chemical analysis of the same. The fragment was wedge shaped, the surface of fracture black, as is the case with igneous rocks containing more or less ferrous iron. The inclined faces were of a light brown,—as might be from exposure

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* Transits of willow leaves across micrometer wires were readily taken. Power 1.

and heat. As the owner of the fragment wished to preserve it, the analysis was made from about .8 grams, and was but partial, as follows:

TiO_2	1.60%	Cr_2O_3	none
SiO_2	57.37	CaO	trace
F_3O	3.69	MgO	1.57
Al_2O_3	27.24	K_2O	6.50
MnO	none	Na_2O	.93
		Ign	1.05
		Total	99.95

But a fraction of a per cent. was soluble in hydrochloric acid, if any. That the iron was in a ferrous condition was inferred from the action of the rock.

Professor Riggs thinks that the presence of Titanic oxide and the high percentage of alkalies are decidedly against its meteoric origin.

Photographic Notes. In *Monthly Notices* for December, Mr. W. E. Wilson suggests a method of recording the transits of stars by photography. He writes, "If a sensitive photographic plate is placed in the focus of a transit instrument close behind the wires, and the image of a star of suitable magnitude allowed to transit across it, the result is a straight black line on developing the plate. If instead of having the plate fixed, we have it so arranged that it can be given a small up and down motion each second, the result on the plate is a broken line, the breaks in which are equal to seconds of time. The motion is given to the plate by an electro-magnet driven by a current sent by the observatory clock. During or after the transit a light from a small electric lamp is allowed to fall through the object-glass on the plate for a few seconds. This gives an impression of the wires superposed on the star transit. With a rough apparatus I find the time of transit can be recorded to ¼ second, and I believe with some care the time could be taken to a very small fraction of a second."

Professor Holden makes the following statement in regard to stellar photography. "It is possible to get excellent definition with a portrait lens over an area of 25 square degrees, and at least tolerable definition can be obtained over 100 square degrees. If the lens is of 6 or 8 inches aperture stars of the 12th, 13th, or even 14th magnitude can be registered without going to excessively long exposures."

The Photographic Times of January 31 publishes the following in regard to Mr. Burnham's work during the eclipse of last December. "Professor S. W. Burnham arrived in New York from his southern expedition to observe and photograph the eclipse, Wednesday night, January 22d. * * * Of the twelve exposures made during the eclipse, twelve good negatives have been secured. Professor Burnham made also a large collection of negatives of the characteristic life and scenery in Cayenne, as well as on many islands of the West Indies."

Anuario del Observatorio Astronomico National de Tayeubayo for the year 1890 has been received. It is the 10th annual of the national Observatory of Mexico, but being in Spanish we can not say much about its contents.

NEWS AND NOTES.

Three important articles are necessarily set over this month, because of unexpected delay in procuring needful cuts to illustrate them. Our engraver has met with serious loss by fire.

Our readers will be interested in the notes from Lick Observatory this month, because of the discoveries announced. Dr. Wilson's article on Lexell's comet adds other features to its study that will attract the attention of American astronomers.

Pioneer Time Service by Observatories. Astronomers and time keepers in Observatories will find interesting reading in a late number of *The Jeweller's Circular and Horological Review* (pp. 82–88), in an article by Lieut. Hiero Taylor, U. S. Navy (in charge of the Government Time Service), under the title of "U. S. Government system of Observatory time." We will notice one point only. Speaking of the history of the time service in this country it is said: "The Naval Observatory was the pioneer in the distribution of time. Other Observatories have since made it a part of their work, and have given, so far as is known, satisfaction to the localities of which they are time centers. In a number of cases they make use of the system which has been adopted by the Naval Observatory, etc." These statements are very erroneous and misleading. By what authority are they published?

Statistics on Observatory Time Service. A few weeks ago, a circular letter asking for facts pertaining to time service was addressed to all, or nearly all, of the Observatories in the United States. The Directors of twenty-one Observatories have already responded giving the desired information from all sources that are especially concerned in the present discussion of Observatory local patronage. It is our belief that it is now time to go straight forward in the speedy settlement of this question on its merits at any cost.

Observatory Local Patronage. We have received a number of interesting statements from those in charge of Observatories depending more or less on their local patronage, which plainly show how they are being affected by the tri-partite arrangement between the U. S. Naval Observatory, the Self-Winding Clock Company, and the Western Union Telegraph Company. For want of space we now give but two instances:

Professor G. W. Hough says: "The Dearborn Observatory maintained a time-service in Chicago for many years, receiving therefrom a considerable annual revenue. Two years ago, the Western Union Telegraph Company so interfered with the Observatory service as to practically destroy all revenue. During the past year the service is entirely discontinued."

From a full and concise statement of Assistant F. W. Very, of Allegheny Observatory, we extract a few sentences, as follows: "The value of

the astronomical instruments employed almost exclusively in time Observations may be put down as $7,500." "The compensation (for time-service has) been, and is now more than ever, the main support of the Observatory, which, without it, would probably be obliged to discontinue its work of original research."

Rotation Period of Jupiter's Red Spot. I obtained my last observation of Jupiter, for this season, on the afternoon of November 26, when, however, the seeing was far from good. Low altitude of the planet and air undulations affected the distinctness of the view, but the red spot was seen to be central at about 3^h 54^m. Comparing this with my first observation this year on May 21 at 12^h 31^m I find the mean rotation period 9^h 55^m $40^s.15$ during the interval of 188.64 days. This corresponds very nearly with the period derived from observations here in 1888, which gave 9^h 55^m $40^s.2$ and proves that the velocity of the spot has remained at a pretty uniform rate during the last two years. The same remark applies to 1887 when I found the rate 9^h 55^m $40^s.5$.

Some of the white equatorial spots are still visible but definition has been rarely good enough to afford satisfactory views of these and other details. The large double belt N. of the equator has shown some curious bright spots and irregularities. The latter appears to rotate in a period very slightly less than that of the red spot though somewhat similar markings just S. of the equator move much quicker. For the latter I found a period of 9^h 50^m 6^s in the autumn of 1880, but subsequent observations proved these spots to be slackening in speed. In 1887 Mr. A. Stanley Williams observed many of them and derived a mean period of 9^h 50^m $22^s.4$.

I have seen a drawing of Jupiter made on September 5 last, by Mr. Keeler with the great Lick refractor, power 315. This drawing is certainly the best and the most replete with detail, of any I have ever seen of this planet. It furnishes ample proof of the defining properties of the 36-inch lens and encourages the hope that much useful work will be done on the planets with this noble instrument. W. F. DENNING.

Bristol, December 14, 1889.

Professor W. Upton, of Brown University, Providence, R. I., is to have a new 12-inch equatorial. We are informed that Mr. George A. Saegmuller, Washington, D. C., has the contract for it. With Professor Howe's 20-inch telescope and a number of other smaller orders on hand, Mr. Saegmuller finds his shop room too small, and is therefore adding a new building for increased facilities.

Mr. William Ireland, San Francisco, California, recently sent us two beautiful positives of the total solar eclipse of January 1, 1889, photographed by himself at Norman. The negative from which they were made was a Carbutt No. 27 plate exposed ten seconds. The lens was a large portrait objective No. 7206, Willard & Co., N. Y., with 5⅝ inches aperture, stopped down to 3⅞ inches, with back focus about 20 inches.

Both positives are from the same negative, and are developed so that one shows the inner corona to the best advantage, and the other the outer

streamers. This portrait lens has since been purchased by the Lick Observatory and was taken to Cayenne, South America, by the Lick observers for use in photographing the eclipse of Dec. 22. As Mr. Ireland suggests it may be interesting to compare the negatives by this instrument made at both eclipses.

Observations of Meteors on Nov. 26 and 27, 1889. I arranged with five other observers in different parts of England to maintain a watch for meteors on these dates in the hope of seeing a few of the *Andromedes* should any be visible. The weather fortunately proved clear, though bright moonlight offered some impediment to the observations. A number of meteors were recorded by the various observers and the paths were re-projected and discussed by Professor A. S. Herschel who found that very few, if any, belonged to the display from Biela's comet. Some early members of the *Geminid* shower were observed from the point 90°+28° and there was a pretty condensed radiant in Eridanus at 57°—9°. A few of the meteors seen appear to have been *Taurids* and there was scattered radiation from about the point 37°+33°. The latter may have included a few of the *Andromedes* and a few meteors from a shower previously seen by me on Nov. 30, Dec. 7, 1885, at 31°+37° near *β Trianguli*. As to the display of *Leonids* nothing was seen of it this year in England owing to cloudy weather.

W. F. DENNING.

Bristol, December 14, 1889.

The Constant of Gravity. Proposition. The space through which a body near the surface of the earth, *in vacuo*, at mean latitude, descends by virtue of the ascending force of gravity is very precisely equal to 2,500 geometric inches = 100 polar cubits = the side of a square geometric acre in $\frac{1}{1000}$ of an hour; thus:

Time in thousandths of an hour.	Acquired velocity. Cubits.	Square of the time.	Total Descent. Cubits.	Difference of squares.	Descent in separate intervals of time. Cubits.
1	200	1	100	1	100
2	400	4	400	3	300
3	600	9	900	5	500
4	800	16	1600	7	700
5	1000	25	2500	9	900
6	1200	36	3600	11	1100
7	1400	49	4900	13	1300
8	1600	64	6400	15	1500
9	1800	81	8100	17	1700
10	2000	100	10000	19	1900

	Cubits.	Acre sides.
So that in $\frac{1}{10000}$ of an hour, total descent =	1 =	$\frac{1}{100}$
" $\frac{1}{1000}$ " " " " " =	100 =	1
" $\frac{1}{100}$ " " " " " =	10000 =	100

and so on, in strict decimal relation with the hour-arc and the half-polar axis of the earth.

I. M. C.

Death of Professor C. S. Lyman. We are pained to learn of the death of Professor Chester Smith Lyman, one of the oldest of the professors of Yale University, which occurred Jan 29, 1890, at his residence in New Haven. He was born in Manchester, Conn., Jan. 13, 1814, entered Yale college 1833, graduated in 1837, superintended the Ellington school for two years, entered Union Theological Seminary, New York, in 1839, was in the theological department of Yale College in 1840, afterwards pastor at New Britain, Conn., health failing, made a voyage to the Sandwich Islands and was at Honolulu in 1846. There he taught the Royal school with Queen Emma as a student, who, when in this country later, visited New Haven to see her old teacher. In 1847 he was in California, in 1848 visited the first scene of the gold discovery at Sutter's mill.

In 1850 he came to New Haven and pursued scientific studies and aided in revising Webster's Dictionary. in 1857 he was appointed Professor of Astronomy and Physics in the Scheffield school in 1871, he constructed an apparatus for describing acoustic curves and made improvements in clock escapements, compensating pendulums and other apparatus. He was the first to observe the luminous ring about the planet Venus when at inferior conjunction. After 1859 he was a number of years president of the Connecticut Academy of Science and in 1870 he was elected honorary member of the British Association for the advancement of science. Professor Lyman retained his position in the chair of Astronomy and Physics in the Yale Scientific School until the time of his death, although on account of ill health he was long unable to perform its full duties.

Yale University Observatory. Part II of Vol I of the Transactions of the Astronomical Observatory of Yale University is an interesting paper prepared by Asaph Hall, Jr., Assistant Astronomer in the Observatory. The subject of the paper is the determination of the orbit of Titan and the mass of Saturn. The instrument used was the Heliometer. The reason for re-determining the orbit of Titan was the difference of result, for the mass of Saturn, obtained by Bessel with the Konigsberg Heliometer, by observing Titan, and that of Professor Hall with the large Washington refractor from observations by Titan and Japetus. The reciprocal of the mass of Saturn's system found by Professor Hall from Japetus, by means of differences of right ascension and declination, was 3481.2 and by distances and position angles 3481.4, from Titan, the values corresponding to the same methods were 3496.3, and 3469.9. The value found, as shown in this paper, is 3500.5 ± 1.44, and the writer thinks there is ground for questioning the results obtained from observations by the large refractor at Washington. The mass obtained for Saturn as given by Chambers' Handbook (last edition) by different authorities is interesting for comparison: Newton, 3021; Laplace, 3359; Bouvard, 3512; Bessel, 3500.5; Jacob for the Saturnian system, 3475, and A. Hall, 3478. We do not know from what source this last value is taken, as the above paper does not mention it. We also notice that the value for Saturn's mass, as given in Young's General Astronomy, is 3490. The Yale value of the mass of Saturn's system is seen to be most nearly in accord with Bessel's given above, and Struve's which is 3500.2 by Japetus, and 3495.7 by Titan.

Erratum. In the Sidereal Messenger for February, page 82, the masses of the components of β Aurigae are given as 0.1 or 0.2, owing to error in writing out the results of the computation, which showed, in fact, that the sum of the masses should be 2.3.

BOOK NOTICES.

ELEMENTS OF DIFFERENTIAL AND INTEGRAL CALCULUS WITH NUMEROUS EXAMPLES. By T. A. Smith, Professor of Mathematics and Physics in Beloit College, Beloit, Wis. 1889, pp. 140.

This new book presents a brief course in the Calculus, prepared on a plan to enable a student to acquire a working knowledge of the elements of the subject, in as brief a time as possible. It does not claim to be original, except in its condensed form, and in the range of its applications.

The range of subjects which this small book presents is about that found in elemental works on the same subject having three or four times its size. It seems to us that the different subjects are too much condensed for the beginner to make much headway without large help from a teacher, in the way of additional explanation. The matter is good, but has the author left room by its gradation and arrangement for the student to work independently enough for his own best and most rapid advancement? Give the young mind a clear and firm grasp of principle, and then try its powers in varied application severely; make the student tired, judiciously, in doing hard things which the teacher knows he has mastered before he leaves him, to secure growth and strength of mind. We are sorry to see so poor and inaccurate a sample of printing. We hope the author will not leave the work as it now appears, but raise it to a standard of excellence easily within his ability to do, as compared with other late works on the same subject.

AN ELEMENTARY TREATISE upon the Method of Least Squares, with Numerical Examples on its applications. By George C. Comstock, Professor of Astronomy in the University of Wisconsin and Director of the Washburn Observatory. Boston, Messrs. Ginn & Company, 1890, pp. 68.

In this work, the reader is given a new method of treating the subject of Least Squares. It was developed by the author in his attempts to so present the subject to students of physics, astronomy and engineering that a working knowledge, based upon an appreciation of its principles, might be acquired with a moderate outlay of time and labor. We think the author properly claims that the ultimate warrant for the legitimacy of his method is to be found in the agreement between the observed distribution of residuals and the distribution represented by the error curve. For other important reasons the analytical demonstrations of the equation of this curve are abandoned, and it is presented as an empirical formula representing the generalized experience of observers. The discussion of these reasons would lead away from the object of this notice. It may be sufficient to say, that the difficulties which the analytical demonstration present to the attention of students generally prove sufficient to absorb their whole attention, and cause them to lose sight of the purpose for which the analysis is conducted.

The author begins his work with a simple example consisting of four observations only, from which observation equations are formed, with suggestions indicating how other similar ones might be made. In this way he derives two important principles.

1 That the adopted values of the quantities which are to be determined must be based upon *all* the data available 2 The adopted values must satisfy the observation equations as nearly as possible Then follow the consideration of the following topics Errors and Residuals The Distribution of Residuals, The Error Curve, The principles of Least Squares, Weights, Normal Equations, Forming and Solution of Normal Equations, Numerical Examples, Probable Error of a Function of Observed Equations, Assignment of Weights, Rejection of Observations, Empirical or Interpolation Formulæ Approximate Solutions and Index to Formulæ

This is a carefully prepared work, and, in our judgment, it presents the subject of Least Squares in the simplest and most direct way to meet the wants of nine-tenths of those desiring to acquire a knowledge of its principles for practical uses Those who would master the theoretical side of the theme will find in a number of accessible treatises abundant room for vigorous mental exercise The neat typography of this book is a credit to all who have had to do with its mechanical finish

NEW PLANE AND SOLID GEOMETRY Revised Edition By G A Wentworth, A M Professor of Mathematics in Phillips Exeter Academy, Boston, Messrs Ginn & Company Publishers, 1889 pp 437

The first edition of Wentworth's Geometry was published about thirteen years ago Since that time, the book has been in such favor that large editions have been printed every year, and the increasing demand for the book has recently brought out a new edition, the copy of which has been wholly rewritten Several points of a minor kind appear here and there, throughout the book, suggested by the experience of some of the best teachers of Geometry in this country. The addition of 700 exercises to this edition is a feature that the instructor will quickly notice This is an excellent book for the class room

A COLLEGE ALGEBRA By J M Taylor, A M., Professor of Mathematics in Madison University Boston Messrs. Ally & Bacon Publishers, 1889, pp 317 Introductory Price $1 50.

This book on Algebra is divided into two parts, the first consisting of eleven chapters covering 121 pages, and embracing about the usual amount of Algebra to enter College The second part is presented in ten chapters having the following titles: Functions and Theory of Limits, Differentiation, Development of Functions in Series, Convergency and Summation of Series, Logarithms, Compound Interest and Annuities, Permutations and Combinations, Probability, Continued Fractions and Theory of Equations.

It will be observed at a glance that the second part of this Algebra treats many of the above subjects by the later and by far the best methods, and many instructors decidedly prefer the methods of limits, so-called to that of infinitesimals, as a mode of explaining the fundamental operations of this delightful analysis. Although we do not we are glad to see an Algebra that gives the next best thing, for there are so many late books on this branch that hold to old methods that we sincerely wonder if they will ever be entirely given up. This book is commended to the attention of teachers.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE U. S. N. ECLIPSE EXPEDITION TO WEST AFRICA.

FRANK H. BIGELOW.

For THE MESSENGER.

I am enabled, by the courtesy of Professor Todd, Director of this expedition, to give your readers a very brief sketch of the progress of events up to this date.

We sailed from New York on the morning of October 16th, in the U. S. S. Pensacola, Captain Arthur Yates commanding, hoping to arrive at St. Paul de Loanda by the 5th of December. It was necessary to take fresh supplies of coal at Horta in Fayal Island, at Porta Grande in San Vincent, at Free Town, Sierra Leone, and at Elminah on the Gold Coast, but we cast anchor before St. Paul on the evening of December 6th. A brief inquiry confirmed our supposition that Cape Ledo would be our proper eclipse station, as it was found that the railroad was incomplete into the interior of Loanda, that the Onanza river steamer had sailed two days before our arrival, besides which it would have been impracticable for us to handle our large supply of material apart from the assistance of the Pensacola. It should be stated frankly that the expedition is greatly indebted to the kindness of Captain Yates and all his officers for continuous and most efficient assistance in making our necessary preparations for the eclipse, which were incomplete by reason of the short time given us by the Government orders in which to make ready. The same good will and help remained with us as long as anything was needed to further the success of the expedition.

Cape Ledo has proved to be an excellent position, free from unhealthful influences and in fact wholly salubrious, as is seen by the circumstance that in eighteen days not a single person in the party and ship's company, numbering in all

about 430, has been ill in consequence of the effects of the climate. This shows that there are some healthy spots on the west coast of Africa. The camp was situated about 150 yards from the beach at the foot of two spurs of a bluff, ascending from east towards the west to an altitude of 100 feet. It included a large Ducker portable house for the polar axis, another for the 40-foot direct photoheliograph, two more for camp and storage houses, a Navy T. V. Transit house, and six tents for ten marines who acted as guard day and night. It may be mentioned that the natives visited us freely and appeared to be innocent and inoffensive people. The programme of work was that our headquarters were on ship board, whence large working parties were sent ashore as needed, the material and instruments landed as required, and in short the resources of the Pensacola were freely turned to our advantage by the courtesy of Captain Yates. The heavy work of constructing the piers and mounting the instruments was done in a few days, the preparation of the dark rooms and adjusting of the pieces of apparatus continued steadily till the beginning of the eclipse.

The apparatus was concentrated in two houses, one under the personal supervision of Professor Todd, the other being intrusted to Professor Bigelow. No attempt will be made to describe the instruments now, but it may be stated that Professor Todd had arranged on his large polar axis as many as twenty-four object glasses, including cameras of all descriptions, photographic, catoptric and dioptric telescopes, four spectroscopes and an actinic duplex telescope. These were all fitted up with pneumatic apparatus for moving the objective covers and changing the plates at the pre-arranged instants of exposure, one end of each telescope being within the dark room, having one side constructed of flexible material to permit following the diurnal motion of the sun. The performance of the polar axis, the Denver clock, and the new pneumatic system was eminently satisfactory. It shows that hundreds of exposures can be made at one station during the instants of totality with the same readiness that an operator has been accustomed to secure a score, and there is no reason why observers should not avail themselves of this method in the future. The forty-foot direct photoheliograph consisted of the Transit of Venus Nagasaki

lens, mounted in a steel spiral weld tube which was supported like a tripod one leg being converted into a clock by a large sand piston and cone. In the dark room was a revolving disk-reticle, with circular plates for ten exposures, controlled by an electric dial and an electric valve which supplied compressed air to a piston. In steadiness, ease of control and geneneral effectiveness the instrument is a great success, and the simplicity of its mounting commends it strongly to field astronomers.

About 110 pictures were secured in the clear intervals between the clouds, for the most part near the 1st and 4th contacts, though thirty were taken about midway between 1st and 2d contacts. Totality was a complete failure, by reason of heavy clouds which formed over the face of the sun as its light was gradually diminished after 1st contact, the sky being perfectly blue in several regions near the horizon, notably in the southeast. The Pensacola, by steaming out to sea about fifteen miles, saw the corona in a partial way and obtained a fair observation of the 2d and 3d contact instants. This mishap is the more aggravating as the Wednesday, Thursday and Friday preceding were magnificent days, Saturday only partially cloudy in the afternoon, and the following Monday and Tuesday fine once more. By common consent it is thought that the climate and meteorological conditions at this station are unusually favorable to such a purpose as our own in the month of December, and there are no regrets that we had not chosen some other position. An English party under Mr. Alber Taylor, of London, was located about an eighth of a mile to the east of us, but no other expeditions were sent to the African coast for observations.*

The other work of the Expedition includes the operations in Meteorology, Natural History, Anthropology, also Magnetic and Gravitation observations, the latter of which will be prosecuted at Cape Town, St. Helena, and Ascension Island.

It is only fair to say that the Expedition is enjoying its

* Mr. Taylor had mounted a 20-inch reflector of 22 inches focal length, and the 5-inch Dallmeyer that has served in earlier eclipse expeditions, and he likewise met with a total failure to make any observations. It is reported that the corona was seen on the river Quanza, some eighty miles from the ocean, but nothing more is known about it.

visit to Africa and profiting by the novel and important experiences through which it is passing

CAPE LEDO, WEST AFRICA, Dec. 28, 1889.

THE OCCULTATION OF JUPITER, SEPT. 3, 1889

WILLIAM H PICKERING *

FOR THE MESSENGER

This occultation was observed at Wilson's Peak with the 13-inch telescope, and eight photographs were secured. They were taken with the enlarging apparatus, on a scale of $15'' = 1^{mm}$, and with an exposure of three seconds each The first and second contacts occurred in the day time and so could not be observed The third and fourth occurred about ten minutes after sunset. This caused the negatives to be somewhat fogged by the light of the sky, so that direct measures were impossible. They were accordingly enlarged to a scale of about $3'' = 1^{mm}$, and measurements made from the enlargements. All the negatives taken immediately after the occultation show the limb of Jupiter next the moon to be decidedly darkened This is conspicuous and could not escape notice. The same limb is also darkened on other negatives taken on previous and succeeding days, and is undoubtedly due to the phase. In the photographs taken when about half of the disc was obscured there is no shade perceptible upon the face of the planet other than the belts.

Two photographs were obtained immediately after the fourth contact, when the following limb of Jupiter was respectively $1''.74$ and $8''.50$ from the limb of the moon Four photographs were taken later when the distance was from $85''$ to $105''$. The line joining the centers of Jupiter and the moon was inclined very nearly 45° to the meridian, so that the two diameters of Jupiter measured radially and tangentially to the moon may be compared directly, without sensible correction for ellipticity of the disc.

Unfortunately the telescope was not pointed so as to bring Jupiter in the center of the plate. With the enlarging apparatus this introduces a considerable distortion; but as Jupiter always occupied the same position upon the plate, it is

* Harvard College Observatory.

presumed that the distortion was the same in all cases. Four measures of each of the two diameters were made upon each of the six photographs. The different measures of the same distance were made at different times, and in no case consecutively. The average deviation of a single measure in a series made upon the same plate is 0″.24. Comparing the four plates where Jupiter is remote from the moon, the average deviation of the mean difference of the two diameters on each plate from the mean difference of the four is 0″.35. The mean difference between the two diameters as measured on these four plates is 1″.85. Assuming the distortion the same, and that this correction applies to all six plates, we find the excess of the radial over the tangential diameter in the six plates amounts respectively to — 0″.75, —0″.54, + 0″.32, + 0″.24, —0″.69, + 0″.12. As the measures of the fifth plate gave a result which was unexpectedly small, it was re-measured. Using this second series of measures the correction for distortion becomes 2″.06, and gives for the six plates the following values, — 0″.96, — 0″.75, + 0″.11,+ 0″.03, — 0″.03, — 0″.09. In other words, when near the moon's limb, the diameter of Jupiter measured in the direction of the moon's center was apparently reduced nearly a second of arc. Should this result be confirmed by future observations it would indicate a highly rarified lunar atmosphere, whose refractive power was about one three-thousandth part that of the earth's.

THE "RED LIGHT."

E. J. BROOKINGS.

For The Messenger.

The remarkable occurrences in the atmosphere which began in the autumn of 1883, and which continued with more or less intensity for a period covering nearly two years have passed into astronomic history under the name of the "Red Light," or "Red Sunsets," and the subject is now most too old to be discussed *per se*. But I noticed in a pamphlet just received from Professor Lewis Swift, entitled "History and Work of the Warner Observatory, 1883–1886," several essays on the subject (previously given to the public through

other sources I presume), all tending to the conclusion that the eruption of Krakatoa was the original cause, except that of Professor Henry C. Maine, of Rochester, N. Y., who maintains the theory that unusual disturbances in the sun and consequent action upon our earth's atmosphere, caused the unusual phenomena.

My object in referring to the subject is, not to enter into a discussion of it, but, as it seems to me, to correct an error of theory which Mr. Maine, in the ardor of maintaining his proposition, has fallen into, viz.: that the peculiar *halo* so long accompanying the sun in his daily revolutions (commonly speaking) during much of the time the phenomena occurred, was the solar corona.

I quote from his essay:

"The persistence of the peculiar halo about the sun for more than a year, while the red sunsets were very unequal, sometimes disappearing altogether, indicates that there must be several factors to produce the sunset phenomena. Some of these factors were less changeable than the others. The halo showed but little change for a long period, although it was noted that on most occasions the Red Light was brilliant at night when the halo was most conspicuous."

He then proceeds to assert an unusual solar energy during the period named, with the consequent effect upon the earth's atmosphere, and in specious argument and reasoning forms the theory that these conditions so intensified and extended the luminosity of the sun's corona that it could thus be seen during the period mentioned, as notice in his concluding remarks which I quote: "Bearing all these facts and theories in mind, is it not probable that the violent solar eruptions during the past five years have so loaded and extended the solar envelope that the nebulosity has become visible, and that the visibility began in the autumn of 1883? The effects of the solar eruptions upon our atmosphere might have been such as to aid in rendering the sun's envelope visible through vapor at an abnormal height. Such conditions explain the persistence of the solar halo, and its changes in form, while the sunset phenomena, which depended partly upon local atmospheric conditions, varied from day to day." * * *

His conclusion is as follows: From all these considerations it would seem that there is a reasonable presumption of a physical connection between the unusual solar activity and the Red Light, and that the one is the principal cause of the other."

The only point I wish to make in regard to the Professor's conclusions is, I fear, one which will upset the whole theory. It is this, that during the same periods, almost, when this solar halo persisted, a *lunar* halo was also distinct and persistent. Now why not ascribe the cause of these disturbances to lunar activity?

I myself was particularly, interested in this almost persistent solar halo, and to satisfy myself that it was at least mostly produced by atmospheric origin, I watched the moon quite as intently, and I noticed that the halos of each corresponded very nearly in periods and persistence. That I am not prejudiced, I would here remark that, at that time, my views of the subject quite closely corresponded with those of Mr. Maine; but were soon dispelled by cumulative evidence on all sides to the contrary.

It is possible that, during the remarkable atmospheric conditions of those two years, the corona of the sun itself might have been seen, in connection with earthly coronas, so often visible in vaporic or other elemental disturbances; but it does not follow that the quite continuous halo was produced by solar energy and solar coronal luminosity; in other words that it was produced by conditions exterior to earth itself. Besides it is well known there have been in other periods of years just as remarkable solar activities without corresponding results like those of 1883–1885.

Mr. Maine's doubts as to the ability of volcanic dust and vapor to persist in our atmosphere for so long a period is not, I think, based upon very good foundation, for I have seen evidences where the fine dust of cities (hardly comparable with the minuteness of volcanic matter) in midsummer, has remained for days in the air, and the smoke of burning forests for months.

The sediment of the Potomac water in spring-time (much to our disgust) will remain for weeks before settling. How much easier, then, would it be for the matter thrown from an immense eruption to an enormous height and in minut-

est condition, to maintain an apparent equilibrium amongst the currents of the upper air.

WASHINGTON, D. C., 1890.

PORTRAITS OF DISTINGUISHED ASTRONOMERS IN WOLFF-LEAVENWORTH COLLECTION OF SYRACUSE UNIVERSITY.

Certain legal technicalities having rendered void a section of the will of the late Gen. E. W. Leavenworth of Syracuse, N. Y. in which he had generously intended to make provision for Syracuse University, his widow, Mrs. Harriet T. Leavenworth, determined that his purpose should not be thwarted, purchased at her own expense the Wolff collection of engravings and presented it to the University. The collection represents the patient work of fifty years of Dr. Heinrich Wolff of the University of Bonn. Early in his student life he conceived the idea of gathering together the portraits of distinguished physicians of all times and countries, and steadily pursued that purpose until the day of his death. By watching the favorable opportunity, he was enabled, by purchase and exchange, to obtain many engravings that rarely come upon the market. On several occasions other collections were purchased and added to his own, so that at his death, when the whole was placed upon the market, it numbered about twelve thousand portraits.

Aside from its interest as illustrating the progress of the art of engraving, this remarkable collection will prove of value to all persons interested in scientific work of any kind. While Dr. Wolff intended it to be first of all a series of portraits of those who had contributed something to the science of medicine, he added portraits of distinguished men of all professions—alchemists, charlatans, astrologers, chemists, physicists, poets, philosophers, mathematicians each find their appropriate place. There are portraits of over three hundred astronomers and mathematicians in the collection, and it is with the thought that it may prove of value to some one interested in the history of Astronomy, that the following list of portraits of the more distinguished astronomers has been prepared. The numbers refer to the catalogue prepared while the collection was for sale at Frankfort on the Main.

134 Bacon, Roger; 12°.
143 Bailey, Francis; standing. Thomas Philipps, p. Th. Lupton sc. Gr. Fol.
220 Bradley, James; Hudson, p. J. Faber sc. Fol.
221 " " " " Tookey sc. 8°.
442 De Moivre, Abr.; J. Highmore, p. J. Faber sc. Fol.
461 Dollond, J.; Wilson, p. Mckensie sc. 12°.
462 " " Posselwaite sc. 8°.
509 Ferguson, James; J. Townsend p. R. Steward sc. Fol.
510 " " Northcote p. F. Haward sc. Fol.
511 " " T. Wright sc. 8°.
516 Flamsteed, Joh; Gibson p. G. Vertue sc. Fol.
517 " " 3 sheets by various engravers, small Fol. 8° and 12°.
608 Gregcry, David. 4°.
633 Halley, Edmund; Murray p. 1712. J. Faber sc. Fol.
634 " " G. Kneller p. G. White sc. Fol.
635 " " 2 sheets. Phillips p. G. Vertue sc. 4° and 8°.
687 Herschel, J. F. W.; H. W. Pickersgill p. W. Ward sc. Gr. Fol.
688 " " after a Photo. Von Pound sc. Small Fol.
689 " William, Abbot p. Ryder sc. Fol.
690 " " after medallion of von Duhamel 8°.
691 " " F. Rehberg, p., 1814. J. Godby sc. Fol.
692 " " 2 sheets. C. Brandt lith. 4° and 8°.
910 Mc Laurin, Collin; 2 sheets. Trotter sc., 1798, and Freeman sc. 8°.
933 Maskelyne, Nevil; 12°.
934 " " 12°.
957 Molineux, William; Sherwin sc. Fol.
993 Newton, Isaac; G. Kneller p. J. Smith sc. 1712 Fol.
994 " " J. Houbracken sc.
995 " " Sitting with book, half fig. Aet. 85. Vanderbank p. J. T. Faber sc. 1726. Fol.
996 Newton, Isaac; G. Vertue sc. 4°.
997 " " half fig. J. Thornhill p. J. Simon sc. 1723 Fol.
998 " " P. Lely p. B. Reading sc. Fol.
999 " " E. Seeman p. J. M. Ardell sc. Fol.
1000 " " G. Kneller p. W. Sharp sc. 4°.
1001 " " 7 sheets by Von Lips, Dupin, Swaine, Kraus and others. Fol. and 8°.
1098 Ramsden, Jesse; R. Home p. P. Jones sc. Gr. Fol.
1253 Taylor, John; F. H. van Hove sc. 8°.
1465 Allemand, John; Nicholas Sebast. Fol.
1502 Arago, Dom Francois; Maurin lith. Fol.
1503 " " " Ambr. Tardien del. et. sc. 1824. 8°.
1504 " " " 2 sheets. Maurin lith. 8°.
1510 Argelander, F. W. A.; C. Mazen lith. 1837. Fol.
1511 " " A. Hohneck lith. 1852. Fol.
1567 Bailly, Jean Silvan; P. M. Alix sc. after David. Fol.
1568 " " " Delpech lith. Fol.
1569 " " " M. Bance sc. Medallion. 12°.
1570-1-2" " " 7 other portraits by various artists.
1736 Bernoulli, James; 2 sheets. 8°.
1737 " John; 6 portraits by various artists.
1765 Bessel, Friedrick Wilhelm; J. Wolf p. E. Mandel sc. Fol.
1766 " " " from another plate. Fol.
1806 Biot, J. B.; Maurin del and sc. Fol.
1807 " " 3 sheets by Bailly, Delpech and Tardien. 8° and Fol.
1823 Blanchino, Francois; Aet 67. 1729. 4°.
1854 Bode, John Elert; Half fig. Kraft del. Lith. Fol.
1855 " " " Kruger del. Olderman lith. Fol.
1856 " " " 2 sheets by D. Berger, 8°, and Malvieux, small Fol.
1957 " " " 4 " " Bolt, Lowe, Weitsch. 8°.
1915 Borelli, Gio Alfonso; Forino del. Fol.

1928 Boscovich, Roger Joseph. 8°.
1938 Bouguer, Pierre; Peronneau p. Miger sc. Fol.
1940 Bouilland, Ismael, Jag. V. Schuppen p. 1697. Fol.
1965 Brahe, Tycho; J. de Ghryn sc. 4°. *Rare.*
1966 " " 4°.
1967 " " J. Larmessin sc. 4°.
1968 " " 5 sheets. 8°.
2079 Burckhardt, Joh. Carl, 2 sheets, J. G. Schmidt sc., 1800, and Lith 8°.
2110 Cagnoli, Antonio; G. Vocchi del. G. A. Correggio sc., 1805. Small Fol.
2162 Carlini, Francesco; R. Hoffmann lith. 1859. Fol.
2174 Cassini, Jean Dominique; Half fig. L. Cossin sc. Fol.
2175 " " " 2 sheets. Beaubran p. N. Dupuis sc., and unknown. 8°.
2243 Clairault, Alex. Claude; entire fig. Carmontel del. Delafosse sc. 1768. Fol.
2244 Clairault, Alex. Claude; Half fig. C. N. Cochin del. Cathelin sc. Fol.
2288 Copernicus, Nicolas; N. Dandeau del. et. sc. Fol.
2289 " " Three sheets. Karcher, Daumont and another. 8° and 12°.
2380 D'Ambert, J.; Pujos del. 1774 Dupin sc. 4°.
2381 " "
2382 " " P. Maleuvre sc. Fol.
2383 " " Cochin del. Watelet sc. 1754. 4°.
2384 " " 3 sheets. Haid sc. Belliard lith. Fol.; and Delpech, lith, 8°.
2420 Delambre, Jean Baptiste Jos.; Quenedy del. Westermayr sc. 8°.
2422 De L'Isle, Jos. Nicolas; Westermayr sc. 8°.
2446 Descartes, Renatus; In cloak. F. Hals p. J. Snyderhoef sc. Fol.
2447 " " Anonymous. Fol.
2448 " " G. Edelinck sc.
2449 " " C. Van Dalen sc. Fol.
2450 " " E. Ficquet sc. 8°.
2451 " " 2 sheets by Benoist and Duhamel 8°.
2452 " " P. Schenck. Fol.
2453 " " Garnerey p. P. M. Alix sc. Fol. The same; J. V. Meurs sc. 4°.
2454 " " 6 sheets by various artists. Fol., 8° and 4°.
2645 Euler, Leonhard; Handman p., 1756. J .Stenglen sc., 1768. Fol. *Rare.*
2646 " " Half length. J. Darbes p. S. Kutner sc. 1780. Fol.
2647 " " 2 sheets. Dupin sc. and Mechel sc. 8°.
2648 " " 3 sheets by Darchon, Holland Pfenninger. 8°.
2676 Fabricius, James; J. M. Bernigeroth sc. Fol.
2750 Flamarion, Camille; Ettline sc. 8°.
2810 Frauenhofer, Joseph von; Waldherr del. Vogel sc. 8°.
2856 Galilei, Galileo; J. Suterman p. G. Cipriani sc. Fol.
2857 " " D. Tintoretto p. N. Schiavoni sc. Fol.
2858 " " Villamaena del. G. P. Beuoist sc. 8°.
2859 " " 6 sheets by various artists.
2879 Gassendi, Peter; A. Mellan del. et. sc. small Fol.
2880 " " The same reduced to 8°.
2881 " " Nauteuil sc. 1658. Fol.
2882 " " J. Lubin sc. Fol.
2883 " " 3 sheets. Title pages to his works. Fol., 8°, 12°.
2889 Gauss, Carl Friedrich; Half fig. Jensen p. Rittmuller lith. Gr. Fol.
3305 Herschel, Friedrich W.; F. Rehberg p. F. Muller sc. Small Fol.
3306 " " " C. Muller sc.
3307 " " " 3 Woodcuts. Fol., 8°.
3326 Hevel, Joh.; Half fig. Jwenhausen p. J. Falck sc. Fol.
3327 " " A. Stech p. L. Visscher sc. Fol.
3328 " " 4°.
3455 Hughens, Christian; Half fig. Edelinck sc.

3477 Hughens, Christian; Eques sc. Fol.
3478 " " from the other side. F. Otteus sc. Small Fol.
3479 " " A. Blootelingh sc. Fol.
3591 Kepler, John; Hondius sc. Fol.
3592 " " 4 sheets, 8°, and a wood cut. Fol.
3654 Kopernik, Nicolay; G. Colzi del. Sulucci lith. Fol.
3719 La Land, Jerome de; Ely del. A. de St. Aubin sc. Small Fol.
3720 " " 2 sheets. Pujos del. Ingouf sc., and Frischins sc. 8°.
3721 La Land, Jerome de; 3 sheets by Bonneville, Dupin and Westermayr. 8°.
3724 Lambert, Jean Henri; half fig. small Fol.
3764 La Place, Pierre Simonde; 2 sheets. Schufft sc. 4°. Westermayr sc. 8°.
3818 Leibnitz, Gottfr. Wilh. von; Scheitz p. J. F. Bause sc. Fol.
3819 " " " " 3 sheets by Haid and others. 4° and 8°.
3820 " " " " 9 " " various artists. 8° and 12°.
3896 Lindenau, Bernhard von; 2 sheets. V. Grassi p. M. Steinla sc. Fol. Scherth lith. Fol.
3909 Lipperhay, Hans; Berckman p. J. V. Meurs sc. 2 sheets. 4°.
3913 Lithou, Jos. Joh.; 2 sheets. Kriehuber p. Pinhas sc. 8° and lith. 4°.
4053 Maupertius, P. L. Moreaude; Tourniere p. J. Daullee sc. 1741. Gr. Fol.
4055 Maupertius, P. L. Moreaude; 3 sheets. Daullee sc. and Derochers sc. 8°. J. J. Haid. Fol.
4068 Mayer, Tobias; 2 sheets by Riepenhausen and Westermayr. 12°.
4341 Olbers, Wilhelm; C. A. Schwartz p. J. G. Huck sc. 1808. Fol.
4342 " " J. G. Pflugfelder p. et sc. 1807. Fol.
4343 " " R. Suhrlandt del. et lith. Fol.
4344 " " 3 sheets by Mackenzie and others. 8°.
4492 Piazzi, Gius; Half fig. R. Focosi del L. Rados sc. Gr. Fol.
4493 " " Bust. Bossi sc. Fol.
4744 Rittenhause, David; Half fig. C. W. Peale p. J. B. Longacre sc. 8°.
5069 Schroeter, J. H.; 2 sheets. Strack del. Tischbein sc. Small Fol.; and anon. 8°.
5075 Schubert, J. T. von; Lithograph. Gr. Fol.
5098 Schwab, Joh. C.; Bollinger sc. 8°.
5312 Struve, W.; C. A. Jensen, lith. 1844. Gr. Fol.
5806 Zach, Franz Xavier von; Anon. 8°.

THE ENGLISH MILE.*

JACOB M. CLARK, C. E.

This itinerary, on account of its lack of geographical correlation and singular dimension, has evoked much interesting discussion, and been the means of bringing to the surface, under new aspects, a variety of important facts.

The reader is referred to a very instructive article in Vol. 25, p. 69, of this magazine,† giving a full abstract of the views of M. Faye, as read before the Paris Academy, "On the Origin of the English Mile."

* Its Relation to the Size of the Earth, and to Ancient Metrics.
† *Van Nostrand's Engineering Magazine.*

In that paper, the writer favors the view that the dimension is traceable to the survey of Eratosthenes, compared with that of Ptolemy; and incidentally, that the surveys were conducted in terms of the Babylonian degree, and by implication, for the purpose of determining its length, or rather the subtense of one minute of arc; that the error in dimension arose partly from misapprehending the relative values of the stadia of different epochs, through disregarding the assumption that the computation of Eratosthenes was based on surveys made with the Egyptian foot* (0.27′ = 10$\frac{3}{4}$ inches), while the survey of Ptolemy was based on the Philetærian foot (nearly 0.36′ = 14$\frac{1}{6}$ inches.)

Much additional light is thrown on the subject through a valuable contribution to these pages, from the pen of Professor Mansfield Merriman ("The Shape and Size of the Earth," *Van Nostrand's Magazine*, Vol. 22, pp. 53–92, 115–128, and 233–241). Reference is more particularly made to the different versions of the earth's circumference by ancient mathematicians on page 58. In the absence of direct evidence to the contrary, the results, the definition of amplitude observed by Eratosthenes, and the chronology,‡ as given by Professor Merriman, must be taken as clear and conclusive.

Hitherto, the moderns have regarded these statements as the results of successive experiments by the ancient geometers, to ascertain what has been supposed to be unknown to them—the length of the terrestrial degree, or, at any rate, the true circumference of the earth; and, on the face of it the discrepancy is certainly glaring enough to justify the impression, and, at the same time to suggest the theory both of serious errors in their work, and confusion among them as to the dimensions of the stadia used in the different surveys.

The true character and object of these operations can only

* The Egyptian foot is uncertain. The dimension above given agrees very fairly with the [illegible] of Malabar, the palm of Malta, Messina, Naples, Sardinia and Nice, the [illegible], the stonecutter's [illegible] of Zug, and the miner's [illegible] of Prussia; dimensions varying from [illegible] (=10.57) inches.

† The Philetærian foot is regarded by Alexander as equivalent to [illegible] inches.

Pliny gives the base of the Great Pyramid at 883 feet; this is correct, Pliny's foot being [illegible] 10.[illegible] English = 10.[illegible]4 geometric inches, by a well known [illegible] of the royal cubit. The Pyramid's base is [illegible] geometric inches = [illegible] polar cubits, representing in polar cubits the exact number of days in the tropical year.

‡ In a recent discussion (Trans. Am. Soc. C. E., vol. XI, p. 415), the writer, adopting this chronology, inadvertently placed Aristotle 200, instead of 100 years earlier than Archimedes.

be understood by reading them in the light of contemporaneous history and in view of the spirit of the times, aided by such knowledge of the actual dimensions made use of as can be obtained or fairly inferred.

It should be borne in mind that, as a rule, conquest has always involved more or less serious interference with the metrics of the people. And, from the nature of the case, this was a prominent feature of state policy among the ancients. So long as a subjugated, but powerful and intelligent people retained the use of their traditional measures, cherished by the philosophers, and indissolubly connected with the mysteries and service of the temple, their complete subjection would be a matter of doubt. But the perils involved in the sudden and arbitrary overthrow of entire systems, were generally, in fact, sought to be avoided by modifications—compromises, under more or less specious and flattering pretexts.

Now as to the measures—the stadia probably used—and the mode of reckoning:

The Greek stadium was ⅛ of their mile of 1,000 paces, or double parade-steps; value = 604⅜ feet. The Romans had practically the same mile. Elsewhere, the stadium was 100 fathoms, and the fathom, generally, 3 cubits. But the Hebrew fathom was 4 cubits.

The Egyptian, Phenician, and Persian cubit was 0.01 of the schœnus, which was equivalent to 145.92 English feet. The Hebrew cubit was $\frac{1}{80}$ of the schœnus.

The Babylonian cubit was apparently the subtense of 1° on a radius of 100 duodecimal feet, or 1,200 inches. Its value would depend on that of the inch. A form of it appears in Egypt, with some uncertainty as to the date of its introduction, under the name of the royal cubit.* The Turin and Nilometer cubits, so called, are versions of it. The dimension was not far from 1.75 feet. A slight modification, to be understood further on, would place it as = 1.75104 English feet.

There would result:

The Egyptian stadium = 437.76 English feet.

The Hebrew stadium = 729.6 English feet.

* The perfect royal cubit is the circumference of a circle upon 9 Egyptian digits as a diameter, the digit being one twenty-fourth of the Egyptian cubit.

The (supposed) stadium on fathom of 3 Hebrew cubits = 547.2 English feet.

The (supposed) stadium on fathom of 3 royal cubits = 525.312 English feet.

Among the peoples concerned, the reckoning, for all general purposes, was purely decimal, except that the Babylonians had the duodecimal mixed up in their system, with alternations of 6 and 10.

To facilitate the view, the different results are arranged in the table in chronological relation with prominent epochs, and in connection with the above lengths of stadia:

Epoch.	Event, etc.	Earth's circumference in stadia	Length of stad English feet
B. C. 538	Babylon taken by Cyrus.		
B. C. 525	Independence of Egypt destroyed by Cambyses.		
B. C. 340	ARISTOTLE	300,000	437.76
B. C. 332	Macedonian Conquest; end of the Pharoahs.		
B. C. 250	ARCHIMEDES	300,000	437.76
B. C. 230	ERATOSTHENES	250,000	525.312
B. C. 146	Greece made a Roman province		
B. C. 90	POSIDONIAS	240,000	547.20
B. C. 30	Cleopatra's death, end of the Ptolemies, Egypt becomes a Roman Province		
A. D. 170	PTOLEMY (in the reign of Marcus Aurelius)	180,000	729.60

With these values of the stadium the circumference in each case is 131,328,000 English feet.

By Clarke's elements of 1878, as quoted by Professor Merriman, the mean circumference is 131,331,455 English feet.

The skill and accuracy of ancient astronomers is strikingly illustrated by the survey of Almamoun, in Mesopotamia, in the ninth century, referred to for illustration by both Professor Merriman and M. Faye. Taking the Arabian mile (palpably a version of Ezekiel's 500 reeds) at Haswell's quotation, 2,146 yards, with the Professor's statement of the result, 56⅔ miles to the degree, the circumference is $2{,}146 \times 3 \times 56\frac{2}{3} \times 360 = 131{,}335{,}200$ feet, a trifle above the ancient and modern, in a total disagreement as to the whole circumference of less than a mile and a half.

Both Egypt and Mesopotamia are fairly situated for apprehending the mean circumference by meridian observations.

Leaving aside, for the moment, the above suggested adjustment of the royal cubit, the question arises pretty distinctly whether the most promising theory to square with all the facts may not, after all, be something like this:

(1.) At the very earliest assignable epoch, the mean circumference of the earth, and consequently its radius, were known with astonishing precision. Under a very perfect system of geometry, the metrics of the ancient leading nations were founded on this knowledge, The opinions of Aristotle and Archimedes were derived from this source, through Egypt.

(2.) After the Macedonian conquest, it became apparent that, by the breaking up and commingling of nationalities, the multiplicity of units was inconvenient and perplexing. The Mosaic and Babylonian cubits were in collision. The "cubit and a hand-breadth" of Ezekiel, by this time widely diffused and popularized, differed from the two-foot rule by about an inch. The Egyptian and Persian cubit was becoming confounded with the Indian* cubit of 18 inches. And the Greek measures were a new element of discord. Eratosthenes was charged by Ptolemy Philadelphus with the work of reform. To satisfy the prevailing preferences for the decimal method, and at the same time strike a reducible mean among the cubits, an itinerary was invented which should be an even decimal of four terrestrial great circles. It is more than probable that the survey of Eratosthenes was simply to test the correctness of the ancient standards and fix the adjustment of the royal cubit. The circumference was already known, according to the Egyptians, and if their account proved correct, the *relation* was apparent beforehand. The royal cubit would have to be six-fifths of the Egyptian = twenty-four twenty-fifths of the Mosaic = 1.75104 English feet.

(3.) This unwieldy division of the circle, unfit for geography or astronomy, along with the strong preferences of the Egyptians, Persians, Hebrews, and kindred races for the

* It is a peculiarity of the purely duodecimal method that, reckoning from the inch, it has no longer dimension than the 12-feet pole or "joktan." And, wherever it has taken root, this dimension, as well as its derivatives by bisection, the valgar fathom, the yard and the Indian cubit, as also the foot when used as units, are, as a rule, but with occasional intermediaries of 3 and 6, reckoned upwards decimally. Its singular distribution—about the Mediterranean, among the islands as Great Britain and Japan, and upon the salients of Africa and Asia—is strikingly suggestive of the maritime enterprise of busy Tyre.

ancient measures, and their wide-spread traditional sympathy as against Babylonian methods, finally broke this system down. Accordingly, after the Roman supremacy was established, and in the reign of one of the later Ptolemies, Posidonias restored the Mosaic cubit, but in a 3-cubit fathom, so that his itinerary was decimally related to the hour-angle. And so far from his survey being the worst measurement of a degree ever made, it serves to verify in a very lucid way the work of his predecessors. The aptness of his system, as an itinerary, is attested by the survival of the Turkish mile, through all vicissitudes, and of its correlative fathom, by dozens of analogues, in the islands and along the Mediterranean and in central Europe. And it may seem significant to many that in the Apocalypse, written 186 years later, the division of the circle by 24 is paramount.*

(4.) Finally, in the reign of Marcus Aurelius, a further attempt at unification seems to have been made by re-instituting the Mosaic itinerary—the leuga of the ancient Gauls and the mile of Sardinia. This was the survey of Ptolemy. Possibly it involved some concession to the Egyptians, in that the schœnus became simply 20 fathoms, instead of 33⅓ as by their ancient method, or 26⅔ as by that of Posidonias. It lacked, however, the key note of Ezekiel's reform—*radius* to be the base of direct and square measure, itinerary to be ruled by the division of the circle.

There seems to be little either in the accounts we have, the necessities of the case, or the character of the rulers under whom these operations were conducted to indicate that they were instituted for any other purpose than that above suggested—verification of the ancient work, and adjustment of the standard for the particular purpose in view at the time. Neither is it apparent that in any of them, the Babylonian degree was either used or its dimension sought (except possibly as to Ptolemy), or that the Egyptian foot, whatever it may have been, or the Philetærian foot or the Greek stadium, were used or referred to at all, or that the geodetic work had any other fundamental base than the ancient public surveys of Egypt, familiar to the learned throughout the whole period of operations, and unquestion-

* See I Chronicles, chaps xxiii, xxiv, xxv, and xxvii. Also Josephus Antiq., Book vii chap. 13, for King David's strict ideas of circular geometry. A similar system is indicated in the dedication of the tabernacle, Numbers vii

ably made with the schœnus. And this view is confirmed by Eratosthenes' definition of amplitude, as quoted by Professor Merriman—$\frac{1}{50}$ of 4 right angles—a decidedly decimal expression, as well as by the general ancient preference for the decimal method.

The English mile, by its dimension, suggests with strong probability that it was at first either equal to 1751 yards,* representing the survey of Eratosthenes, or else 1824, like the Turkish mile, the itinerary of Posidonias; and that it took its present form at the time the English forced the 36-inch yard into their land measure by means of the invention of Gunter's chain. The former is the more probable of the two.

ILLUMINATION FOR A POSITION MICROMETER.

G. W. HOUGH.†

FOR THE MESSENGER.

Incandescent lamps, for illuminating the circles and micrometer wires of an equatorial telescope, have been in use for some years. When, however, a primary battery is employed for generating the electricity, I am informed that the trouble of keeping the battery in order is a serious obstacle to its success. The employment of storage cells obviates all difficulties.

During the past five years I have used three simple storage elements, each consisting of two sheets of lead 4 × 6 inches covered with red-lead, and hung in a glass or stone jar, containing dilute sulphuric acid. These cells are charged by seven gravity elements; the whole kept constantly connected in series.

A storage cell of this kind will yield a current of about three ampères, and the lead plates will last two years without removal. My cells have been in constant use for operating the printing chronograph, door bells and for other pur-

* = 12 Egyptian stadia = 3600 Egyptian cubits = 1½ Russian versts.

The Russian correlation is: Earth's *mean circumference* = 3750 Swede miles = 37,500 versts = 18,750,000 sagine = 56,250,000 archine = 900,000,000 verschok. The verschok is one-tenth of the Egyptian cubit.

The Asiatic pic (= 26.24 geoemtric inches) is one ten-thousandth of the ancient *parasang*.

The co-relations of ancient typical systems come out clear through ancient zodiacs and cyclar methods of time-reckoning.

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poses. They also give satisfactory results with a one or two candle incandescent lamp. Commercial storage cells may now, however, be purchased of a capacity of 25 ampère hours and upwards, which, of course, would be preferable. Three cells connected in series with seven gravity elements will be charged at the rate of one to two ampère hours in one day. If more electricity is required the number of the charging gravity elements may be increased.

At the old site of the Dearborn Observatory in Chicago, I used a small gas burner for illuminating the wires of the position micrometer. The light was fairly under control and generally satisfactory.

After re-mounting the 18½-inch refractor on the new site at Evanston, not having gas in the building, I started with an old oil lamp, which sometimes smoked, was frequently blown out, and was generally in the way when not measuring. I accordingly decided to try electricity. A telegraph line carrying a No. 8 copper wire having been erected between the Observatory and the Physical Laboratory, the distance being half a mile, I was able to make use of the storage battery located at the latter place. An incandescent lamp of one candle power was inserted in one of the arms of the position micrometer, first placing a disk of deep red glass in front of the lamp. A resistance coil of five ohms was then prepared and subdivided in five equal parts, so that any position of this resistance could be introduced in the circuit, at the will of the observer. One wire was connected with the mounting of the telescope and carried down the tube to the lamp. The other wire was brought up at the base of the pier and loosely coiled when not in use. The free wire was left of sufficient length to reach the eye-end of the telescope in any position. When measures are to be made the loose wire is connected with the lamp; it being necessary to detach it only when the telescope is reversed. Both lines might be permanently attached to the telescope, as has already been done by Grubb and others, but the loose wire answers every purpose.

By passing *all* the light through deep red glass, one gets a clean field with scarcely any stray light used by means of the resistance coil, which is fastened to one of the counterpoise arms, within reach of the observer, one can instantly

get any degree of illumination, a very great desideratum in dealing with difficult double-stars or faint satellites. I have now used this method of illumination for some months, and it is found to be so much superior to either gas or oil that I should be very unwilling to go back to the old plan.

We expect, in a short time, to connect the Observatory with the public electric light wires and use incandescent lighting both for the equatorial and the meridian circle.

Observatories which cannot have access to commercial lighting, may easily charge a few storage cells, for micrometer illumination. An incandescent lamp, such as I use, requires a current of about five volts and one ampère.

Eight gravity elements joined in series against three commercial storage cells, and kept constantly connected, would easily furnish all the light required for an equatorial micrometer.

A COMPOUND WEDGE PHOTOMETER.*

E. J. SPITTA, L. R. C.†

The idea of employing a wedge of neutral-tinted glass as a photometer has occurred to many observers—Dawes, Capt. Abney, and others—and notably of late years to Professor Pritchard, of Oxford, who has produced with such an instrument his well known *Uranometria Nova Oxoniensis*, a catalogue of the relative brightness of the brighter stars north of the equator. But the use of such an instrument has always been limited hitherto to the comparison of the relative intensities of such points of light as the stars present, its employment upon objects of sensible area being foreign to the ideas and requirements proposed in its construction. Having, however, attempted to use a photometer of this description upon disks of small but of various areas illuminated by a known amount of light, the discordances of the results forced upon me the necessity of modifying the construction of the photometer in a way which I believe will extend its sphere of usefulness. It is not within the scope of this paper to give any detailed account of the many

* From the proceedings of the Royal Society.

† Communicated by Capt. W. de W. Abney, C. B., F. R. S. Received November 8, 1889.

experiments I have made with several wedges, but it is sufficient to say that the wedge-form itself has been fully proved to be an important factor in the production of the discordances to which reference has been made, for the following reasons:—

A point of light from its very definition implies that no sensible portion of the wedge is occupied in its passage, but it requires very little thought to perceive that when an area of sensible dimensions is being dealt with this is by no means the case. Morever, an elementary inquiry suffices to point out that if the area possess a considerable diameter the light emanating from its lateral portions will impinge on different thicknesses of the wedge, as shown to an exaggerated degree in fig. 1, where AB is the transverse diameter

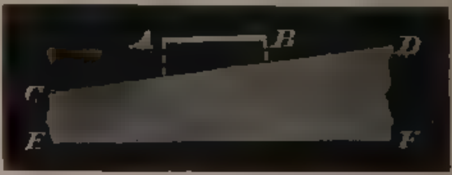

FIG. 1.

of the area, and CDEF the portion of the wedge employed. It is evident if the differences in intensity be required between two disks of the same diameter this condition of things would not affect the validity of the final results, but it is equally apparent that were the disks of differing diameter the values obtained could not but be seriously affected. Let it be presumed that two such different-sized disks were under consecutive examination, as shown in fig. 2, AB representing the diameter of one and CD that of the other. In the case of AB it is manifest that the extreme limb B would be fainter to all appearance than the oposite edge A, because the light issuing from it has to traverse a portion of the wedge EF, thicker and so more dense than E'F'. On consideration, it is equally obvious that the limiting margin A will be the last to appear as the wedge is made to move from right to left till disappearance takes place, the position technically spoken of as "the point of wedge extinction." But if CD, the larger disk, be illuminated with light of the same initial intensity as fell on AB, it is evident that the

point of wedge extinction (technically so-called) for CD at the limb C will not be at the same wedge-reading as in the previous case, in fact, disappearance would not occur until the portion of the wedge corresponding to the line E′F′ had been moved to occupy the position shown by the line E″F″. Hence, when ascertaining what is termed the wedge-interval in the direct comparison, say, of the relative intensities of a large and small disk, it is very obvious an error entirely due to the physical nature of a wedge must inevitably result, such error being in direct proportion to the amount of shift

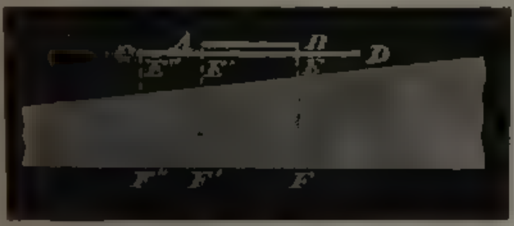

FIG. 2.

required, which depends upon the relative differences in diameter of the disks under observation. Nothing is here said of the difficulties of observation, which are enormously increased by the different apparent intensities of the light at the extremities of the diameter parallel to the length of the wedge, because I merely wish to call attention to the error resulting from the employment of the wedge-form itself.

To apply a correction under these circumstances was not deemed expedient, even if found to be practically possible; hence the removal of the source of error has been arrived at by devising an instrument of different construction, to which the term Compound Wedge Photometer has been applied, and of which the following is a brief description:

Two very thin wedges of neutral-tinted glass are made to slide past one another with a uniform rate of motion by the turning of a single milled-headed screw, the idea of the arrangement being diagrammatically set forth, so far as the wedges themselves are concerned, in fig. 3, where it will be seen that any amount of density, within certain limits, can be obtained by equal movement of the two wedges, although a uniformly absorptive area in all parts of the field is rigidly maintained. In the figure, ABC is shown as one

wedge, DEF the other, and VIEW the field of view. A cursory inspection of the arrangement at once reveals its most salient advantages, and the fact that any sized disk within the limits of the field of vision will be observed by the same density of neutral-tinted glass at any and all parts of its image, and hence that the cause of error spoken of as arising from the use of a single wedge is at once removed.

An instrument so constructed has been subjected to several months' crucial testing, and I have no grounds for thinking it does not fulfil the requirement for which it was devised.

FIG. 3

In its final form the arrangement differs from that usually met with as suggested by Professor Pritchard, for it is supplied with a rotating disk of metal, perforated at intervals to allow the permanent insertion of pieces of nutral-tinted glass of different thickness, each of which can be evaluated for magnitude and used as a constant. Besides, it is fixed upon the occulting eye-piece, a device for limiting the aperture at the eye-end of a telescope, or for occulting any portion or portions of the field of view, and which I have fully described in vol. 45 of *Monthly Notices of the Royal Astronomical Society*.

The vacancy on the Council of the Royal Society caused by the death of Father Perry, has been filled by the election of the Astronomer Royal.

NOTICES FROM LICK OBSERVATORY.

Announcement of the discovery of the rotation period of Mercury, by M. Schiaparelli.

On the 8th of December, 1889, the *Accademia dei Lincei** of Rome held a special sitting, which the King and Queen of Italy attended in order to hear a discourse by M. Schiaparelli on his discovery of the rotation period of the planet Mercury.

From a report of this meeting and from a short paper in the *Astronomische Nachrichten* the following brief account is condensed:

The rotation periods of the planets Mercury and Venus must be fixed, if at all, by the observation of the spot on their surfaces. Neither of these planets is ever to be found at any considerable angular distance from the sun, so that they must be observed in the twilight or in the day-time. At all Observatories the images of planets in the day-time are wavering and unsteady and at some stations (as at the Lick Observatory, for example)† daylight observations can almost never be made to advantage. At Milan, M. Schiaparelli has been able to observe Mercury some 150 to 200 times in the years 1881-6, with the eight-inch telescope; and since that time he has used the eighteen-inch telescope, which has confirmed his earlier conclusions.

The fundamental facts relating to the rotation of the planets are:

I. If Mercury is observed on two consecutive days the aspect of its spots is identical or nearly so; and the same is true when the interval between observations is two, three or four days, etc. This fact of observation can be explained by either one of three hypotheses: (*a*) the rotation period of Mercury is about twenty-four hours; (*b*) or the planet makes two or more rotations in this period; (*c*) or the rotation is so slow that an interval of two or three days makes no appreciable alteration in the position of the markings.

II. The observations at Milan showed Professor Schiapar-

* Galileo was one of the original members of this Academy (*dei Lincei*—of the Lynxes—of the sharp-eyed ones) which was named after the fantastic manner of the day.

† See *Publications of the Astronomical Society of the Pacific*, Vol. II, p. 27

elli, to his satisfaction, that the motion of the spots on the apparent disc was too slow to permit of the possibility of the hypotheses *a* or *b*. It followed therefore that the rotation period was of *many* days.

III. Observations in 1882-3 confirmed in 1886-7 showed that the planet revolved about the sun at least somewhat as the moon revolves about the earth, namely: in turning always the same face, or nearly the same face, to the primary body. The observations themselves were so difficult that it was impossible to prove that Mercury revolved on its axis *exactly* in the period of one revolution in its orbit (as in the case of the moon). Professor Schiaparelli takes the sidereal period of Mercury (87 9693 days) at once as its rotation time, although his observations might be satisfied by a period some four hours or so different from this longer or shorter.

IV. The observations were too difficult to permit the determination of the position of the rotation axis, but all his drawings agree with the assumption that the axis of rotation is approximately perpendicular to the plane of the orbit. It is certain that the axis is not inclined as much as 23° or 25° (like the earth's or Mars') and it is not likely that the inclination varies from 90° by as much as 8°.

V. All the observations tend to demonstrate that the rotation of the planet on its axis is uniform; from which datum, combined with the notable eccentricity of Mercury's orbit, it follows that there must be a large libration in longitude with respect to the radius-vector. The period of this libration is eighty-eight days and its amplitude is twice the maximum equation of the center or, 47° 21′.

The author dwells on the extreme difficulty of seeing the faint markings at all, and of depicting them when seen, but gives a planisphere of the hemisphere turned toward us. On the equator three points are marked, O (center of the disc) and two points A and B, 23°41′ from O, and on either side of it. O is the point turned towards the sun (the point which has the sun in the zenith) at the times of perihelion and aphelion; A and B are the two points which have the sun in the zenith at the times of greatest positive or negative libration.

Considering the difficulty of seeing the spots on Mercury

at all it is not easy to give any well-founded opinion as to their nature. They may simply depend upon the diverse materials and the structure of the solid strata of the surface as in the case of our own moon. But, as Mercury is known to have a dense atmosphere, Professor Schiaparelli thinks that it would not be unreasonable to conclude that they might be analogous to our own seas. With regard to this point, he says: "We have in the case of Mercury (as in Mars) a world which is sufficiently diverse from our own, which receives light and heat from the sun, not only in a greater amount but in a different manner from the earth; and where life, if so be life exists there, finds conditions so different from those to which we are accustomed that we can scarcely imagine them. The perpetual presence of the sun almost vertically above certain regions, and its perpetual absence from other regions, appears to us to be something intolerable. But we must recollect that such a contrast should produce an atmospheric circulation which is at the same time stronger, more rapid and more regular than that which sows the elements of life on the earth, and that on this account it may come about that an equilibrium of temperature is produced over all the planet which is far more complete than with us."

The foregoing is a very brief summary derived from the important and elegant papers which have already been published in advance of the more elaborate memoir, in which Professor Schiaparelli will discuss all his observations for the nine years 1881–1889. As early as 1882 M. Schiaparelli announced to one of his correspondents (M. Terby) his discovery in the verses which follow:

> *Cynthiæ ad exemplum versus Cyllenius axe*
> *Æternum noctem sustinet, atque diem:*
> *Altera perpetuo facies comburitur æstra,*
> *Abdita pars tenebris altera sole caret.*

In 1888 Professor Schiaparelli asked the attention of the astronomers of the Lick Observatory to the inferior planets, and Mr. Schæberle, Mr. Barnard, and myself have observed Venus and Mercury in the day-time on a very great number of occasions with the Meridian-Circle and with the twelve-inch equatorial, but with little success. For reasons which I have given in full in the Hand-Book of the Lick Observa-

tory (page 26) we shall never be able to make delicate observations in the day-time at Mt. Hamilton. A station on one of the very small coral islands of the South Pacific Ocean has the very best conditions for this class of observations, and a mountain Observatory has the very worst. On only one occasion during the past two years was it worth while to turn the great telescope upon Venus in the day-time, and for a very few moments the view was somewhat better than it had been in the twelve-inch. If the observations of M. Schiaparelli require confirmation an expedition to one of the smaller *atolls* of the Pacific would yield the surest and the quickest results. E. S H.

BAILEY'S BEADS.

LEWIS SWIFT *

For THE MESSENGER

This curious phenomenon, always accompanying total and annular eclipses of the sun, is, if carefully observed, one of the most striking of the many phenomena visible on such occasions, and as, to my mind, no satisfactory explanation has been advanced for its production, and, inasmuch as I have studied carefully at three different eclipse occurrences its formation, I have thought that a short paper on the subject might not be wholly uninteresting to the readers of THE SIDEREAL MESSENGER.

When the moon, advancing eastwardly over the sun, has reduced the sun's eastern limb to a very narrow crescent, it suddenly breaks up into many luminous objects extending from end to end of the crescent, and bearing, sometimes, so strong a likeness to a string of beads, that they have received the name of "Bailey's Beads," because first accurately described by Mr. Francis Bailey in 1836, though seen long before by Halley and others. Some four or five seconds before the advancing moon uncovers the western limb of the sun, they are in like manner produced at that edge of the disk, and present nearly the same appearance as at the eastern limb.

For a long time, perhaps quite naturally, the cause assigned was the visibility of the sun through the interstices of

* Director of Warner Observatory, Rochester, N Y

the lunar mountains. This theory was, until recently, from its very simplicity, received with almost universal credence, though after three or even two careful observations of this phenomenon, I think no astronomer would endorse it, as the idea that twenty or thirty lunar mountains are so evenly spaced and so precisely alike as to so admit the passage of sunlight that they shall produce contours so alike and so symmetrical is not tenable.

Perhaps I cannot do better than to reproduce my descriptions of them as observed at Denver, Colorado, in 1878 (as reported to Professor Colbert and published by the Chicago Astronomical Society in that year,) and, also, as seen at Nelson, California, on January 1, 1889.

"Several seconds previous to the formation of the beads, I observed near each end of the solar crescent a phenomenon which I have never seen described in any of the books, and, though reminding me of the "Black Drop" which I saw at the last transit of Mercury, yet it was very different from the latter. Please allow me to describe it. Imagine a long and very narrow crescent cut in a door between two rooms, one dark, the other brilliantly lighted, the observer being in the dark one. The appearance was as if two concealed persons in the lighted room, one on each side of the crescent, were busy in protruding and then withdrawing a series of long, slim, opaque objects like writing pencils. Only twice did I see the images appear opposite each other, as is always the case with the black drop. These appearances continued for about two seconds and then, after ceasing for a second, recommenced farther from the end of the sun's limb, now reduced to a much narrower crescent, but the images were shorter and larger and more irregular in size. This lasted only about a second and again ceased as if waiting for a grand *denouement*, and then came the formation of Bailey's Beads, beginning simultaneously at each end of the crescent, now only a curved line of silver light, and regularly and quickly meeting at the center they seemed to give a succession of quivers and instantly vanished.

These luminous beads appeared to be square (trapezoidal) and from the center each way decreased in a regular geometrical ratio, and, could one-half of them have been superimposed upon the other, they would have agreed in curvature,

size, distance, shape and brilliancy. When I take into consideration the exact uniformity of their formation as to time and the other similarities above noted, I cannot subscribe to the generally received opinion that they are the sun's light seen through the interstices of the lunar mountains. The intelligent reader will not be slow to conceive how serious and numerous are the objections against receiving as true so improbable a theory, especially as those formed at the beginning are precisely like those at the end of totality."

The following report to Professor E. S. Holden, now incorporated in Lick Observatory Eclipse volume, gives their appearance as seen from my station at Nelson, California, which was as unlike that of my former observation as two things can well be. I quote from a manuscript which, in its final revision, was slightly changed:

"BAILEY'S BEADS."

"There has been much speculative writing concerning this singular and, at times, beautiful phenomenon observed at every total and annular eclipse for, at least, a century. The usually assigned cause is the shining of the sun through depressions between lunar mountains, a theory which, when compared with observed facts, has no support. As I saw them in 1878, every one was trapezoidal in shape and differed in size only, being mere points at each end of the cresent, but increasing gradually and regularly towards its center. At the California eclipse they bore no resemblance to those seen at Denver, for, instead of being trapezium shaped they, at both second and third contacts, resembled a curved series of dotted i's or, more exactly the letter a (dot and dash) of the Morse telegraphic alphabet, thus: . — . — . — . — . —. Professor Charles A. Schott says of those seen in 1869, "I would particularly notice their great regularity in width, outline and distribution." Professor D. G. Eaton says, "Bailey's beads were very conspicuous Just before totality the thin cresent was broken by *dark lines shooting out from and perpendicular to the edge of the moon.*"

From the above quotations added to observations of my own, I am irresistibly led to the conclusion that they, like the color of the protuberances, are not seen alike by all, and

that the true cause has never been arrived at. Were I, however, to hazard an opinion, it would be that they result from a phenomenon closely allied to, if not identical with, that causing the "Black Drop." It is also quite likely that diffraction may have much to do with it and possibly may be its sole cause. Were the usually assigned reason the true one, as there are mountains all round the moon, then, on the occasion of an annular eclipse, when the moon so nearly equals the sun in size as to render the annulus exceedingly narrow, the "Beads" should be seen all round the moon. Again, long before a total phase is reached, the ends of the crescent, all the time reduced to a hair-like fineness, ought to reveal them, which is not the case."

On both of the above occasions, the same telescope and eye-piece were used, viz: A power of 35 on a 4½ inch achromatic contracted to three inches. At the Denver eclipse, when the two supposed intra-mercurial planets were discovered I believed and published that the magnifying power used was 25. Several months afterward a measurement showed it to be 35. I had misunderstood Mr. Gundlach, its maker, who says he informed me correctly of the power.

Warner Observatory, Rochester, N. Y., March 18, 1890.

TIME SERVICE.

G. W. HOUGH.*

For THE MESSENGER.

In the Jewelers' Journal and Horological Review appears an article entitled, "U. S. Government System of Observatory Time," by Lieutenant Hiero Taylor, U. S. Navy. The following statement is made: "The Naval Observatory was the *pioneer* in the distribution of time. Other observatories have *since* made it a part of their work, and have given, so far as is known, satisfaction to the localities of which they are the time centers. In a number of cases they make use of the system which has been adopted at the Naval Observatory. This system and the methods by which its objects are accomplished are known as the Gardner System of Observa-

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tory Time. It has been adopted by the Government for its time balls and time signaling service, as it is the simplest and most certain known for the automatic distribution of time."

I think if the writer of the above paragraph had made a little inquiry as to what had been done by other Observatories in the United States in the matter of furnishing time to the public, he would probably have been more careful in his statement.

The time service of to-day, like everything else, has been a gradual development, beginning with the invention of the telegraph.

The first step was the transmission of signals for longitude; the second, the automatic transmission of signals by means of a clock and the invention of the chronograph.

It is not my purpose to give a detailed history of the progress of time distribution in the United States but simply state what was done at one Observatory.

In the years 1856-58 Dr. B. A. Gould, Director of the Dudley Observatory, at Albany, N. Y., arranged with the New York Central Railroad for a time service, and procured the necessary clocks and other apparatus. Owing to Dr. Gould's retirement from the Observatory, the system was never put in practical operation. When I went to the Dudley Observatory in the year 1860, I found two clocks provided with cams and electrical attachments for setting the hands, daily or hourly. I believe this method was the invention of Moses G. Farmer. The same plan is now in general use with some slight modification in mechanical construction. I also found a signal clock with a disk in the second's hand shaft having a single notch, so that automatic signals could be transmitted once each minute.

In the year 1859-60 time balls located in New York City and on the Capitol in Albany were dropped at noon of each day by means of signals sent from the Dudley Observatory. The signals were sent by hand. The New York time ball was soon after discontinued.

In the year 1861 I put the necessary connections in a mean time clock so that a signal would pass only once in twenty-four hours, and so arranged with switches that it could be sent in any hour or minute. This clock was used

for dropping time balls, located in the Capitol and at the foot of State street in the city of Albany. This method, which was entirely automatic, was in use for a couple of years, when the ball in the Capitol was discontinued. It was found from experience that the time balls were of comparatively little use to the public.

In the year 1864 I arranged a mean time clock to send automatic signals hourly, or more frequently if necessary. As I believe this system of signals was among the first ever devised, it may be desirable to state definitely what they were. The necessary mechanism was placed in the mean time clock so that, on the fifty-ninth and sixtieth minutes of each hour, the circuit was opened and closed every two seconds from the fiftieth to the sixtieth second. The breaks in clock beats were about one half second in length. The system was especially arranged in this manner so that time could be sent over a line of telegraph without interfering with the ordinary commercial business, except during the twenty seconds in each hour when the signals were passing.

The signal in the fifty-ninth minute called the attention of the operator so that time could be taken in the following minute. In case a message was being transmitted when the clock signals were passing over the line, it was only necessary to stop sending during the ten seconds, after which the message could be resumed.

This system was first put in operation on a line of telegraph connecting the Observatory with a jeweler in the city of Albany.

In the year 1866 the Western Union Telegraph Company put the Dudley Observatory on a commercial wire connecting the cities of Albany, Troy, etc., and communicating with the general Western Union office and the railroad offices in the city of Albany. And from 1866 to [illegible] this system of time distribution was in successful operation at the Dudley Observatory. At noon of each day the time was sent by the central office over the main telegraph lines in every direction. From 1856 to 1866 the Dudley Observatory time was used on the New York Central and Hudson River railroads, and subsequent to 1866 on all the railroad lines centering in Albany. In [illegible] the Observatory was connected with the fire-alarm office in the city of Albany, [illegible]

clock signals were also transmitted. The fire-alarm office provided mechanism for striking the church bells at 9 A. M. and 9 P. M. daily on Observatory time.

The foregoing facts and dates may be found in the Annals of the Dudley Observatory, Vols. I and II.

AN APPROXIMATE SOLUTION OF EULER'S EQUATION FOR PARABOLIC MOTION.

O. C. WENDELL.*

FOR THE MESSENGER.

The form in which Euler's equation to be solved by trial, is given in Watson's Theoretical Astronomy, is expressed in the following six equations:

$$\tau = k(t'' - t) \qquad \eta = \frac{2\tau'}{(r + r'')^{\frac{3}{2}}}$$

$$k = \frac{2\tau'}{r + r''}\mu \qquad d = (k^2 - A^2)^{\frac{1}{2}}$$

$$r = \left\{\left(\frac{d + c}{b}\right)^2 + B^2\right\}^{\frac{1}{2}} \quad r'' = \left\{\left(\frac{d + c''}{b''}\right)^2 + B''^2\right\}^{\frac{1}{2}}$$

The method usually adopted in the case of a first orbit, as is known, is to assume $(r + r'')$ equal to 2 and then to solve the above equations several times in succession until the desired result is reached, but when a number of trials are neccessary, as is generally the case, and especially when the problem converges slowly, the process becomes laborious and consumes considerable time. A very short abridgement leading to a close result as a first assumption I have found in the following way:

If in equation 4 we substitute the value of k as given in equation 3, we have

$$d = \left\{\frac{(2\tau'\mu)^2}{(r + r'')^2} - A^2\right\}^{\frac{1}{2}}$$

Then, assuming that $\mu = 1$ and that r and r'' are equal we have:

$$d = \left\{\frac{2(\tau')^2}{r} - A^2\right\}^{\frac{1}{2}} \qquad (1)$$

an equation in which r is the only variable.

* Harvard College Observatory.

Again Equation 5 of the original equations can be better transformed as follows:

$\frac{d+c}{b}$ is the sine of an angle, φ suppose, of which B is the cosine, the angle being formed by the comet's radius-vector and a perpendicular let fall from the sun upon a line joining the comet's with the corresponding earth's place.

Then we have $\frac{d+c}{bB} = \tan \varphi$ (2)

and $r = B \sec \varphi$ (3)

By solving the last three very simple equations twice with an assumed value of r at the beginning and then making use of ordinary correcting formula $q = q_0'' - \frac{a^2}{a' - a}$ where a represents the difference between the first and second and a' between the second and third values of r, a close approximation to r is reached by a very few minutes labor for use in the more complete formulæ. In these trials only three or four place logarithms need be used. I have employed this abridgment with advantage in several orbits, the most extreme case being that of the orbit of Barnard's comet discovered July 7, 1885.

My assumption for r was 1, or 0.000 for log r. Two solutions, however, of the above equations, with the additional use of the correcting formula, above mentioned, gave me 0.40 for log r or 2.5 for r itself, the exact value of the mean of the two radii-vectores being, as subsequently determined, 2.5230.

Harvard College Observatory, March 8, 1890.

Temperature of the Moon, from studies at the Alleghany Observatory by Professor S. P. Langley, with the assistance of F. W. Very. We have been favored by a copy of Part 2, Vol. IV., National Academy of Sciences, third memoir, entitled "The Temperature of the Moon," and also a copy of a paper published in the American Journal of Science in December, 1889, which is supplementary to, and completes, the investigation of 1883, and ontinued for the next four years. The principal conclusion drawn from is most intricate and long continued research, is that the mean temperare of the sunlit lunar soil is much lower than has been supposed, and is st probably not greatly above zero Centigrade. The attention that se excellent papers have attracted in foreign scientific journals is very tering to the author and is justly the pride of American scholarship.

CURRENT CELESTIAL PHENOMENA

THE PLANETS.

Mercury, passing through superior conjunction April 9, will not be visible to the eye during the early part of the month of April. On May 5 it will be at greatest elongation east, 21 18′ from the sun. The declination of the planet at this elongation will be about 24° north, so that it will be in a most favorable position for observation. It will be seen in the west for several evenings from 8^h to 9^h, a little north of the west point of the horizon, not far from the Pleiades and the red star Aldebaran The latter part of this month will be a most favorable time for the study of the surface of Mercury in full sunlight, with the aid of a telescope Probably the best views can be had between 5 and 7 P. M. The diameter of Mercury's disk will vary from 5 2″, April 15, to 10″, May 5.

Venus may also be seen in the west in the evening from 8 to 9, and is in excellent position for daylight observations of the gibbous phase. The diameter of her disk will increase from 10″ to 11″, while the illuminated portion of the disk decreases from 0 970 to 0 927. Venus and Mercury will be in conjunction April 25 at 10 P. M , Mercury being 2°04′ north of Venus. They will be in conjunction again May 10 at 1 A. M., Mercury being 1°45′ north of Venus. On May 5 at 3 A M Venus and Neptune will be in conjunction, Venus north 2 02′. We shall have thus three planets in the same portion of the sky, two of which, though small, are so near as to be visible to the unaided eye, the other, though much larger, so distant as to be invisible to the eye and very faint in the telescope.

Mars will be best seen toward the south about midnight. He is among the bright stars in the constellation of Scorpio, a little northeast of the red star Antares. He will be in conjunction with the moon April 9, 6 A M., 0°45′ south of the latter, and again May 6, 2 P M , 1°44′ south. On May 1 Mars will be about 54,000,000 miles distant from the earth, his apparent diameter will be 17 2″ and his phase 0.969.

Jupiter is still among the faint stars of Capricorn, visible in the southeast in the morning. His apparent polar diameter on May 1 will be 37 6″. Jupiter will be at quadrature, 90° west from the sun, at midnight April 30. We give this month tables of the phenomena of the Satellites, but have at hand no ephemeris for the transits of the great spot.

Saturn will be at quadrature, 90° east from the sun, May 18. He is in excellent position for observations in the early evening, situated in the constellation of Leo near the bright star Regulus. The angle between the plane of Saturn's rings and the line joining the centers of earth and Saturn will be at its greatest for this opposition, 11°20′, in May. The apparent major axis of the outer ring will then be 41″ and the minor axis 8″.

Uranus will be at opposition to the sun April 14, and therefore in position to be observed during the whole night. He is in the constellation of Virgo about one third of the way from Spica to Kappa Virginis.

Neptune will be too low in the west to be well seen. It will be in conjunction with Mercury, about 4°14′ south of the latter, on May 3 at 4 P. M.,

and in conjunction with Venus 2°02′ south, on May 5 at 3 A. M. Neptune is in Taurus about half way between the Pleiades and the Hyades.

We give this month the places of the four planetoids Ceres, Pallas, Juno, and Vesta, taken from the "Companion to the Observatory" for 1890. These are given at intervals of twenty-four days near the time of opposition. The "Berlin Jahrbuch" for 1892, which gives the daily places of the planetoids in 1890, has not yet come to hand. The opposition of Vesta occurred January 18; Pallas will be at opposition April 29, Ceres May 17, and Juno May 26.

MERCURY.

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
April 25	3 18.1	+20 18	5 34 A.M.	1 03.2 P.M.	8 32 P.M.
May 5	4 16.0	+23 56	5 34 "	1 21.5 "	9 09 "
15	4 43.8	+23 54	5 23 "	1 09.8 "	8 57 "

VENUS.

April 25	3 18.9	+18 19	5 44 A.M.	1 03.8 P.M.	8 23 P.M.
May 5	4 09.4	+21 27	5 40 "	1 14.8 "	8 49 "
15	5 01.5	+23 37	5 42 "	1 27.6 "	9 13 "

MARS.

April 25	16 47.0	−22 30	10 02 P.M.	2 29.7 A.M.	6 58 A.M.
May 5	16 42.5	−22 50	9 20 "	1 46.0 "	6 12 "
15	16 32.8	−23 02	8 32 "	12 57.0 "	5 22 "

JUPITER.

April 25	20 50.9	−18 08	1 49 A.M.	6 37.3 A.M.	11 26 A.M.
May 5	20 55.0	−17 53	1 12 "	6 01.8 "	10 52 "
15	20 57.6	−17 45	12 35 "	5 25.0 "	10 16 A.M.

SATURN.

April 25	9 59.3	+14 05	12 42 P.M.	7 43.2 P.M.	2 44 A.M.
May 5	9 59.4	+14 04	12 03 "	7 04.0 "	2 05 "
15	10 00.3	+13 57	11 25 A.M.	6 25.5 "	1 26 "

URANUS.

April 25	13 30.5	− 8 49	5 45 P.M.	11 13.8 A.M.	4 42 A.M.
May 5	13 29.0	− 8 40	5 04 "	10 33.0 "	4 02 "
15	13 27.6	− 8 32	4 23 "	9 52.3 "	3 22 "

NEPTUNE.

April 25	4 05.8	+19 14	6 27 A.M.	1 50.8 P.M.	9 15 P.M.
May 5	4 07.2	+19 19	5 49 "	1 12.9 "	8 37 "
15	4 08.7	+19 23	5 10 "	12 35.1 "	8 00 "

THE SUN.

April 25	2 12.6	+13 21	4 59 A.M.	11 57.8 A.M.	6 56 P.M.
May 5	2 50.8	+16 24	4 45 "	11 56.5 "	7 08 "
15	3 29.8	+18 59	4 32 "	11 56.2 A.M.	7 20 "

CERES (1)

April 17	16 08	−12 47	9 11 P.M.	2 28 A.M.	7 35 A.M.
May 11	15 50	−12 43	7 18 "	12 30 "	5 42 "

PALLAS (2)

April 5	15 35	+18 07	7 22 P.M.	2 41 A.M.	10 00 A.M.
29	15 24	+23 43	5 05 "	12 51 "	8 37 "
May 23	15 04	+26 11	2 57 "	10 57 P.M.	6 57 "

JUNO (3)

1890	R. A. h m	Decl. ° ′	Rises. h m	Transits h m	Sets h m
April 5	16 53	− 7 31	10 20 P. M.	3 54 A. M.	9 28 A. M.
29	16 46	− 5 25	8 30 "	2 12 "	7 54 "
May 23	16 28	− 3 40	6 32 "	12 21 "	6 10 "

VESTA (4)

	R. A. h m	Decl. ° ′	Rises. h m	Transits h m	Sets h m
April 17	8 59	+25 31	10 19 A. M.	6 15 P. M.	2 11 A. M.
May 11	8 29	+23 59	9 22 "	5 10 "	12 58 "

THE MOON

	R. A. h m	Decl. ° ′	Rises. h m	Transits h m	Sets h m
April 20	3 08.5	+14 30	6 07 A. M.	1 13.3 P. M.	8 27 P. M.
25	7 38.6	+23 55	9 21 "	5 22.9 "	1 23 A. M.
30	11 48.9	+ 6 49	2 25 P. M.	9 12.8 "	3 49 "
May 5	16 00.6	−19 16	8 16 "	1 14.2 A. M.	6 03 "
10	20 27.6	−22 32	12 38 A. M.	5 15.9 "	9 50 "
15	1 06.1	+ 1 48	3 19 "	9 32.8 "	3 55 P. M.

[The above tables give local times for the Central Meridian and latitude +44° 28′.]

Minima of Variable Stars of the Algol Type.

	R. A. h m s	Decl. ° ′	Approx. Central Times of Minima
U Cephei	0 52 32	+ 81 17	Apr. 19, 8 P. M., 24, 8 P. M., 29, 7 P. M.; May 4, 7 P. M., 9, 7 P. M.
S Cancri	8 37 39	+ 19 26	May 2, 8 P. M.
δ Libræ	14 55 06	− 8 05	April 20, 8 P. M., 27, 8 P. M.; 30, 4 A. M.; May 7, 3 A. M., 14, 3 A. M.
U Coronæ	15 13 43	+ 32 03	April 22, 3 A. M., 29, 1 A. M.; May 5, 11 P. M., 12, 8 P. M.
U Ophiuchi	17 10 56	+ 1 20	April 18, 2 A. M., 18, 10 P. M., 23, 2 A. M., 23, 10 P. M., 28, 3 A. M., 28, 11 P. M.; May 3, 3 A. M.; 3, 11 P. M.; 9, 1 A. M., 14, 1 A. M.

Phenomena of Jupiter's Satellites.

d	Central Time h m				d	Central Time h m			
April 16	4 23 A. M.	III	Ec.	Dis	May 4	1 16 A. M.	III	Sh	In
21	4 26 "	I	"	"		4 50 "	III	Sh	Eg
22	2 32 "	II.	Tr.	Eg	6	2 15 "	II	"	"
	3 02 "	I.	Tr.	In	7	2 42 "	I.	Ec.	Dis.
	4 02 "	I	Sh	Eg	8	1 17 "	I.	Tr.	In.
	5 22 "	I.	Tr	Eg		2 18 "	I.	Sh	Eg
23	2 32 "	I	Oc	Re		2 37 "	II.	Oc	Re
27	2 38 "	III	Tr	In		3 37 "	I	Tr	Eg
	2 47 "	IV.	Ec	Dis	9	12 49 "	I.	Oc.	Re
29	2 17 "	II	Tr.	In	13	1 09 "	IV	Ec	Re.
	2 30 "	II	Sh.	Eg	15	12 31 "	III	Oc.	Dis.
	3 35 "	I.		"		1 50 "	I	Sh	In
30	4 27 "	I	Oc	Re		3 09 "	I	Tr	In.

Occultations Visible at Washington.

Date	Star's Name	Magnitude	IMMERSION Wash. Mean T. h m	IMMERSION Angle f'm N. P't °	EMERSION Wash. Mean T. h m	EMERSION Angle f'm N. P't °	Duration. h m
April 22	105 Tauri	6	7 30	109	8 32	189	1 01
23	1 Geminorum	5	9 11	128	9 59	239	0 48
25	82 "	6½	8 36	110	9 47	281	1 11
May 13	B.A.C. 17.	6	15 16	11	15 51	300	0 35

Phases of the Moon.

			Central Time. d	h	m	
New Moon	1890	April	19	2	06	A. M.
First Quarter	"	"	26	10	52	P. M.
Full Moon	"	May	4	3	09	P. M.
Last Quarter	"	"	11	10	22	A. M.
Apogee	"	April	26		Noon.	
Perigee	"	May	8	4	24	P. M.

Ephemerides of Saturn's Satellites.

[Computed by A. Marth, Monthly Notices R. A. S., vol. L, No. 1, p. 57. Reduced to Central Time.]

Apr. 15	1.2 p. m.	Rh. w.
	6.0 p. m.	Mi. n.
	10.1 p. m.	Te. s.
16	7.4 a. m.	Di. n.
	4.1 p. m.	Rh. s.
	4.7 p. m.	Mi. n.
	5.3 p. m.	En. n.
	8.7 p. m.	Te. n.
17	4.1 a. m.	Tit. s. 38″
	3.3 p. m.	Mi. n.
	4.2 p. m.	Di. s.
	7.2 p. m.	Rh. e.
	7.4 p. m.	Te. s.
18	1.9 p. m.	Mi. n.
	6.0 p. m.	Te. n.
	6.6 p. m.	En. s.
	10.3 p. m.	Rh. n.
19	1.1 a. m.	Di. n.
	4.7 p. m.	Te. s.
20	1.4 a. m.	Rh. w.
	9.9 a. m.	Di. s.
	3.3 p. m.	Te. n.
	7.9 p. m.	En. n.
	10.4 p. m.	Mi. s.
21	4.5 a. m.	Rh. s.
	12.4 p. m.	En. s.
	2.0 p. m.	Te. s.
	6.8 p. m.	Di. n.
	9.1 p. m.	Mi. s.
22	7.6 a. m.	Rh. e.
	12.6 p. m.	Te. n.
	7.7 p. m.	Mi. s.
	9.3 p. m.	En. s.
23	3.6 a. m.	Di. s.
	10.7 a. m.	Rh. n.
	11.3 a. m.	Te. s.
	1.7 p. m.	En. n.
	6.3 p. m.	Mi. n.
24	9.9 a. m.	Te. n.
	12.5 p. m.	Di. n.
	1.9 p. m.	Rh. w.
	4.9 p. m.	Mi. s.
	9.3 p. m.	Tit. n. 36″
Apr. 24	10.6 p. m.	En. n.
25	8.6 a. m.	Te. s.
	3.0 p. m.	En. s.
	3.5 p. m.	Mi. s.
	5.0 p. m.	Rh. s.
	9.3 p. m.	Di. s.
	10.2 p. m.	Di. ed.?
26	7.2 a. m.	Te. n.
	2.2 p. m.	Mi. s.
	8.1 p. m.	Rh. e.
27	5.9 a. m.	Te. s.
	6.2 a. m.	Di. n.
	11.2 p. m.	Rh. n.
28	4.6 a. m.	Te. n.
	3.0 p. m.	Di. s.
	4.0 p. m.	Di. ed.?
29	2.3 a. m.	Rh. w.
	3.2 a. m.	Te. s.
	11.8 p. m.	Di. n.
30	1.9 a. m.	Te. n.
	5.4 a. m.	Rh. s.
May 1	12.5 a. m.	Te. s.
	8.5 a. m.	Rh. e.
	8.7 a. m.	Di. s.
	9.7 a. m.	Di. ed.?
	6.6 p. m.	Mi. n.
	7.0 p. m.	En. n.
	11.2 p. m.	Te. n.
2	11.6 a. m.	Rh. n.
	5.2 p. m.	Mi. n.
	5.5 p. m.	Di. n.
	9.8 p. m.	Te. s.
3	2.5 a. m.	Tit. s. 37″
	2.7 p. m.	Rh. w.
	3.8 p. m.	Mi. n.
	8.4 p. m.	En. s.
	8.5 p. m.	Te. n.
4	2.4 a. m.	Di. s.
	3.4 a. m.	Di. ed.?
	12.8 p. m.	En. n.
	2.4 p. m.	Mi. n.
	5.8 p. m.	Rh. s.
	7.2 p. m.	Te. s.
May 5	11.2 a. m.	Di. n.
	1.1 p. m.	Mi. n.
	5.8 p. m.	Te. n.
	8.9 p. m.	Rh. e.
6	2.1 p. m.	En. s.
	4.5 p. m.	Te. s.
	8.1 p. m.	Di. s.
	9.1 p. m.	Di. ed.?
7	12.0 a. m.	Rh. n.
	3.1 p. m.	Te. n.
	9.6 p. m.	Mi. s.
	11.0 p. m.	En. s.
8	3.2 a. m.	Rh. w.
	4.9 a. m.	Di. n.
	1.8 p. m.	Te. s.
	3.5 p. m.	En. n.
	8.2 p. m.	Mi. s.
9	6.3 a. m.	Rh. s.
	12.4 p. m.	Te. n.
	1.8 p. m.	Di. s.
	2.8 p. m.	Di. ed.?
	6.9 p. m.	Mi. s.
10	9.4 a. m.	Rh. e.
	11.1 a. m.	Te. s.
	4.8 p. m.	En. s.
	5.5 p. m.	Mi. s.
	8.1 p. m.	Tit. n. 35″
	10.6 p. m.	Di. n.
11	9.8 a. m.	Te. n.
	12.5 p. m.	Rh. n.
	4.1 p. m.	Mi. s.
12	7.5 a. m.	Di. s.
	8.4 a. m.	Te. s.
	8.5 a. m.	Di. ed.?
	2.7 p. m.	Mi. s.
	3.6 p. m.	Rh. w.
	6.2 p. m.	En. n.
13	7.1 a. m.	Te. n.
	4.3 p. m.	Di. n.
	6.7 p. m.	Rh. s.
14	5.7 a. m.	Te. s
	7.5 p. m.	En. s.
	9.8 p. m.	Rh. e.

En. = Enceladus; Di. = Dione; Jap. = Japetus; Mi. = Mimas; Rh. = Rhea; Te = Tethys; Tit. = Titan; c. = conjunction; e. = eastern elongation; w. = western elongation; n. = north of center of planet; s. = south of center of planet. The conjunctions of the three innermost planets with the ends of the ring take place in the case of Mimas about 3.0h, Enceladus, 3.2h, Tethys, 3.5h before and after the predicted conjunctions with the center, which are not observable.

A New Planetoid No. 288 was discovered by Luther at Hamburg, February 24.4650 in right ascension $10^h\ 17^m\ 37.1^s$ and declination + 14° 53′ 20″. It is of the eleventh magnitude having daily motion in right ascension — 48′ and in declination + 6′.

New Minor Planet (289?). A new minor planet of 13th magnitude was discovered by Charlois March 10.346, right ascension $9^h\ 41^m\ 23^s.6$, declination 8° 53′ 33″.

New Minor Planet (290 ?). A new Minor planet of 13th magnitude or fainter was discovered by Palisa, of Vienna, March 20.4787, in right ascension $12^h\ 24^m\ 5^s.4$, in declination $+ 2°\ 7'\ 28''$. Daily motion in right ascension—25′, in declination—10′.

Sunspots. A good sized group of spots was noticed near the northeast limb of the sun March 4 containing one large spot with two umbræ, and surrounded by brilliant faculæ. This spot was conspicuous for several days but on the 13th had so diminished as to be seen with difficulty.

Solar Prominences, February, 1890. Number of observations, 9; greatest number of prominences seen in one day (single observation), 11 on the 13th; least number of prominences seen in one day, 1 on the 26th; height of highest prominence observed, 80″, on 26th; mean number of prominences daily, 4.5; prominences distributed as follows:

	North.	South.
Between 0° and 10°	4	2
" 10 and 20	3	6
" 20 and 30	2	3
" 30 and 40	7	1
" 40 and 50	0	6
" 50 and 60	2	7
" 60 and 70	0	0
" 70 and 80	0	0
" 80 and 90	0	0
Total	16	25

Chromosphere during month low and billowy. E. E. READ, JR.

Camden Observatory, March 1, 1890.

Smith Observatory Observations. The following solar observations were made with helioscope in February, 1890; power, 98.

1890.	90 m. M. T.	Groups.	Spots.	Faculæ.	Seeing.	Remarks.
1 Feb.	2 P. M.	1	1	0	Fair.	Gran. good.
6 "	2 15 "	0	0	1 gr.	"	Fac. near N. E. limb.
8 "	2 20 "	0	0	0	"	
9 "	2 15 "	0	0	0	Very poor.	Thin clouds.
10 "	10 A. M.	0	0	0	"	
11 "	10 45 "	0	0	1	Good.	Fac. faint; gran. good to limb.
12 "	2 55 P. M.	0	0	1	Fair.	Fac. bright on E. limb; gran. good.
13 "	2 25 "	0	0	0	"	No distinct fac.; gran. fair.
14 "	11 20 A. M.	0	0	0	Very poor.	Glimpses through clouds.
15 "	12	0	0	1	Good.	Fac. brilliant on S. W. limb; whole surface very sharp and clear.
16 "	3 P. M.	0	0	0	"	No distinct fac.; "faculissimæ" in many places.
17 "	11 15 A. M.	0	0	0	Clouds.	Impossible to make out anything definite.
18 "	11 30 "	0	0	0	"	Impossible to make out anything definite.
20 "	11 15 "	0	0	0	Poor.	Gran. poor and dif.
21 "	2 00 P. M.	0	0	0	"	Haze and clouds.
23 "	2 45 "	0	0	0	Fair.	Gran. sharp at intervals; coarse in center of disk.
24 "	3 45 "	0	0	1	Poor.	Fac. near N. E. limb.
28 "	2 00 "	0	0	0	Lt. clouds.	Could not make out gran. structure.

Smith Observatory, Beloit College, CHAS. A. BACON.

Beloit, Wis., March 10, 1890.

Dartmouth Notes. The group of sun-spots which appeared by rotation on March 4th is interesting on account of its high latitude. It was preceded on the third by an eruptive prominence the height of which I estimated as 60″, and by other fainter diffuse prominences at nearly the same position-angle. These, I suppose, are to be considered the "elevation" view of the bright faculæ which surrounded the spot for the first few days. When the group was first seen at 1:30 (Eastern standard time) on March 4 the penumbra was invisible on the western side (*i. e.* the side furthest from the limb), thus showing distinctly the effect of depression. As groups which give data for finding the solar drift in this latitude are rare, (Carrington based his conclusions on observations of three groups), I append the values found for the heliographic latitude and longitude from day to day:

March 4	3:35 P. M.		$\lambda = 32°\ 33'$ north.	$l = 194°\ 51'$
5	2:15		32 33	193 38
7	2:00		32 39	194 9
8	2:10	Nucleus A.	33 1	194 17
		Nucleus B.	32 13	195 15
		Mean	32 42	194 46
9	12:30	Nuclues A.	33 18	192 1
		Nucleus C.	31 46	192 47
		Mean	32 32	192 24
10	12:15	Nucleus A.	33 43	191 41
		Nucleus C.	31 42	192 43
		Mean	32 43	192 12

From this it appears that the drift is about the same in λ and l, as found by Carrington, but before final conclusions are drawn it will be well to wait for observations separated by a longer interval, if the life of the spot is sufficient to permit this.

Judging from the diagram of the observations at Greenwich published in the *Monthly Notices* for November, 1889, I conclude that so large an area has not been disturbed in so high north latitude since 1874, excepting, perhaps, 1880.

I would like to make note of a fine meteor reported to me by several persons as observed at 8:55 P. M. (E. S. T.) on Jan. 20th. It appeared as large as the moon, of a white color, and fell through some 40° S. E. in Orion lighting up the sky, and finally broke into several pieces.

Hanover, N. H., March 11, 1890. EDWIN BRANT FROST.

Proper Motion of the Double-Star South 503.—J. E. Gore has shown in *Monthly Notices*, Vol. 50, No. 1, that the proper motion of the double-star South 503, is 0″.65 per annum in the direction of position-angle 138°.04.

Orbit of Struve 228. J. E. Gore says: Recent measures show that the binary star, Struve 228, has described about 120° of its apparent orbit since its discovery in 1829. The orbit as computed by Mr. Gore is as follows:

$P = 88.73$ years	$\Omega = 84°\ 49'$
$T = 1906.03$	$\lambda = 51\ \ 36$
$e = 0.5311$	$a = 0''.98$
$i = 70°\ 59'$	$\mu = +\,4°.057$

COMET NOTES.

Comet 1885 II. In *Astronomische Nachrichten*, No. 2952, Dr. Berberich gives two sets of definititive elements of this comet, the first without making any assumption as to the eccentricity, resulting in a hyperbolic orbit, the second assuming the orbit to be parabolic. The first satisfies best the normal-places, with the exception of the last one, which depends upon a single observation. The parobolic elements, however, satisfy all the observations nearly as well and the last one better than the hyperbolic elements.

	(*A*) Hyperbola.	(*B*) Parabola.	
T	1885 Aug. 5.574653	Aug. 5.718966	Berlin mean time.
ω	178° 27′ 01.61″	178° 30′ 04.47	Mean Equinox 1885.0
☊	92 17 09.67	92 17 45.72	
i	80 39 26.33	80 37 34.31	
$\log q$	0.3992904	0.3991079	$q = 2.50673$
e	1.0028519	1.0	

Comet 1884 III (Wolf.)— In *Astronomische Nachrichten*, No. 2953. there is an interesting paper on the "Former Orbit of Comet 1884 III," by R. Lehmann-Filhes. This comet is now moving in an ellipse with a period of about 6½ years, but has not been seen at a previous apparition. Professor Krueger showed that it must have passed very near Jupiter in 1875 and that its orbit must have been greatly changed then. Herr Lehmann-Filhes has computed the perturbations by Jupiter and has endeavored to calculate the orbit which the comet had before its encounter with the planet in 1875. We give below the elements of the present orbit by Thraeu and those derived by Lehmann-Filhes for the former orbit.

Epoch	1884 Sept. 27.5		1875 April 5.0	
M	352° 31′ 59″.16	1880.0	226° 32.6′	1880.0
☊	206 18 29 .17		208 26.8	
ω	172 42 30 .62		157 12.4	
π	19 00 59 .79		5 39.2	
i	25 15 42 .82		29 26.6	
ϕ	34 07 14 .69		23 01.2	
$\log e$	9.7489155		9.592245	
$\log a$	0.5539247		0.620840	
μ	523.74469″		415.668	
Period	2474.48807 d = 6.78 yrs.		3117.8 d = 8.54 yrs.	

It will be seen that the eccentricity and major axis of the orbit have been greatly changed. The comet was before 1875 moving in a much larger ellipse of which the least distance from the sun was over 2.5 times that of the earth. This would account for the invisibility of the comet in former years.

The Comets of 1889.

Designation		Synonym.	Discoverer.	Date.	Perihelion.	☊
Comet 1889	I	*e* 1888	Barnard,	Sept. 2	Jan. 31.2091	357°25′15″
	II	*b* 1889	Barnard,	Mar. 31	June 10.8067	310 42 10
	III	*c* 1889	Barnard,	June 23	June 20.7816	270 58 04
	IV	*e* 1889	Davidson,	July 19	July 19.3072	286 10 30
	V	*d* 1889	Brooks,	July 6	Sept. 29.7436	17 58 30
	VI	*f* 1889	Swift,	Nov. 17	Nov. 29.6641	331 26 40
1890	I	*g* 1889	Borrelly,	Dec. 12	Jan. 26.869	12 16

	ω	i	q	e	Computer	Reference
I	340°27′40″	166°22′13″	1.81489	1.001086	Berberich	A.N. 123, 280
II	236 04 49	163 50 26	2.25559	1.0	Millesovich	A.N.123, 207
III	60 08 05	31 12 50	1.10240	0.956665	Berberich	A.N. 123, 77
IV	345 51 44	65 57 30	1.03949	0.994742	Campbell	A. J. IX, 119
V	343 18 56	6 04 00	1.95023	0.472726	Knopf	A.N. 123, 123
VI	69 29 13	10 03 21	1.33831	0.631214	Zelbr.	A. N. 123, 255
I	197 22	57 35	0.2740	1.0	Hill	S. M. IX, 88

Comet a 1889 was discovered by Brooks January 14 in right ascension 18ʰ 04ᵐ declination south 21° 20′, but was not afterward seen by anyone.

Ephemeris of Comet 1889 I (continued from page 135).

	α app.			δ app	log r	log Δ
	h	m	s	° ′		
April 17	18	42	06	−8 20.8	0.7135	0.6806
21		39	30	8 11.0		
25		36	39	8 01.6	0.7192	0.6747
29		33	34	7 52.6		
May 3		30	15	7 44.0	0.7248	0.6697
7		26	43	7 35.9		
11	18	22	57	−7 28.2	0.7304	0.6660

A new comet was discovered by William R. Brooks March 19.875, in right ascension 21ʰ 9ᵐ, in declination + 5° 35′.

NEWS AND NOTES.

We are sorry to set over matter again because of the failure of our engravers to furnish the quality of work demanded.

We have not space for much in hand about the United States Naval Observatory position in regard to the Western Union time service of this country. But we will say as sure as the public press does its duty, and the astronomers of the United States have courage enough to stand by their convictions and the right, something will be done pretty soon.

U. S. Scientific Expedition to West Africa. We have received bulletins Nos. 2, 6, and 8. The first refers to the meteorological work of the expedition and was prepared by Professor Cleveland Abbe under date of 18th of October, 1889. No. 6 was by the same author concerning Water-spouts and bears date 7th November, 1889. Bulletin No. 8 was prepared by Professor Frank H. Bigelow, subject, Eclipse Photography, and bears date 20th November, 1889. It gives a brief summary of the units, the formulæ, and the process of interpreting the intensities of the light of the corona, for the guidance of the observers of the eclipse for which they were preparing.

Death of Professor Jacob Ennis. By a copy of the Houston Daily *Post*, recently received, bearing date of Jan. 19, we have the sad news of the death of Professor Jacob Ennis, at his home in Houston, Texas. Professor Ennis garduated at Rutger's College, joined the Dutch Reformed

church, by which he was sent to the islands of Java and Sumatra as a missionary, where he labored four years. Returning to his native country, he was elected Professor of Natural Science in the National Military College at Bristol, Pa., and later he became principal and proprietor of the Scientific and Classical Institute of Philadelphia· in which position he spent the best part of his life. He also occupied, for some years, the chair of Physical Science in the State Normal School of Shippenburg, Pa. His life was quiet, simple, dignified but laborious. He found considerable time outside of routine duty for study and original investigation in physical and speculative astronomy, as the titles of the following papers show: "The Meteors and Their Long Enduring Trails," "Elements of Sidereal Astronomy," "Electrical Constitution of our Solar System," "Physical and Mathematical Principles of the Nebular Theory," "Origin of the Power which causes Stellar Radiation," "Four Great Eras of Modern Astronomy," and many others on kindred topics. Professor Ennis wrote several articles for this journal which have appeared from time to time, and only last year he was preparing an elaborate article on the later phases of astronomical research which we had the pleaure of perusing, in part, before it was completed. Professor Ennis will be missed from a large circle of friends both east and west.

A Simple Approximate Formula for the Refraction. I have for several years given to my class in practical astronomy a formula for the refraction in zenith distance which is so convenient for many purposes that it deserves to be more widely known. The formula is:

$$\text{Refraction} = \frac{b}{470 + t} \tan z$$

where b is the barometric pressure expressed in thousandths of an English inch, t the temperature of the air in degrees Fahrenheit, and z the apparent zenith distance. For all ordinary values of the temperature and pressure this expression represents Bessel's refractions between the zenith and 75° zenith distance, within a second of arc (1″) and is therefore abundantly accurate for all sextant work and for most observations with other portable instruments.

An equivalent expression in different units is:

$$\text{Refraction} = \frac{21.5\, b}{273 + t} \tan z$$

where b is to be expressed in millimeters and t in degrees Centigrade.

In each case the formula gives the value of the refraction in seconds of arc. Somewhat greater accuracy can of course be obtained by writing $\tan (z - f\, r)$ in place of $\tan z$, Bradley's refraction formula, but it does not seem necessary to introduce this refinement. GEO. C. COMSTOCK.

Washburn Observatory, Feb. 26, 1890.

The Mechanics of the Solar System is the title of a neatly printed and illustrated pamphlet of seventy pages, having the title of "The Principles of Mechanics as Applied to the Solar System." The author's name is not given, but the name of his agent is P. Ervine, of San Francisco, California.

This pamphlet aims to account for the motions of the planets and other celestial bodies on the principles of attraction *and* repulsion, chiefly active in the plane of the equator of the sun for the planets, and in the equatorial plane of the planets respectively for their systems of satellites. The first question that the practical astronomer would ask is: What has the author observed in the mechanics of the solar system that calls for the principle of repulsion in the very general way in which he uses it? If the principle of gravitation, as now known, will explain nearly all the phenomena to which this pamphlet refers satisfactorily, is it not unnecessary to make the assumption of *two* forces acting in a particular plane to do the same thing? We admit that only those who have some independence in the higher mathematics can satisfactorily handle the abstruse problems of the motions of two or three celestial bodies, but such scholars are well agreed as to the general principles that govern the motions of all the bodies of the solar system and many more. Again, we think, the author has probably not read that excellent book entitled "Astronomy without Mathematics," by Sir Edmund Beckett, or he would not have written as he did about the "Tides." There is another grand book, now in the course of publication, which takes up this matter of the tides more fully and thoroughly than the one just named, and that is the "Old and New Astronomy," begun by the late Professor Proctor about two years ago. Over half of the book is in print, in pamphlet form, and was temporarily suspended at his death.

The author's attempt to explain some hard questions in astronomy is certainly a creditable one, and what he has said is perfectly clear, and his illustrations are especially well drawn to represent his ideas. The MESSENGER encourages all such honest effort, though it be necessary to begin again almost anew.

Fresnel's Mirror Experiment. In the March number of the *American Journal of Science* Albert A. Michaelson has a brief article entitled, "A Simple Interference Experiment," which physicists generally will read with profit. The difficulty of performing the experiment to show light interference has long been recognized by professonal skill, but we have a method now by the genius of Michaelson, that places this beautiful experiment easily within the reach of unskilled persons who may, by his method, obtain excellent results. This is quite important when one remembers that the Fresnel mirror experiment is the incontestible proof of the wave theory of light.

In *Monthly Notices* for January, Professor Holden publishes an article on the photographic apparatus of the great Lick equatorial. This istrument is now provided with a compound slide-rest as a means of moving the photographic plate in order to keep the star images "fairly round." Photographs can be taken on the scale of one minute of arc to sixteen-hundredths of an inch. Mr. Barnard has made positive enlargements of lunar photographs which show the moon twice as large as at the principal focus. Some features of these enlargements bear examination with a high power, making it possible for the astronomer to study the lunar surface at his leisure with a power of more than eleven hundred diameters.

In Charles B. Hill's lecture before the Cosmos Club of San Jose may be found an interesting historical sketch of astronomical photography. Mr. Hill goes back fifty years in the record of photographic effort in astronomical lines, and traces its history to the present time. Speaking of lunar photography he says: "To photograph even the moon, it was formerly necessary to make an exposure of, say half an hour. The modern dry plate is so much more sensitive that better and sharper pictures are now made in one fiftieth of a second." The results of photographic work are discussed under the following heads: Photographs of the Sun, Transit of Venus, Total Solar Eclipse, Stars and Nebulae, and Star Maps.

Jonathan Young Scammon of Chicago died March 17, 1890, at the age of nearly 78 years. He was the father of the Chicago Astronomical Society and as such his memory rightly finds place in the permanent records of science in this country. He was the President of the Chicago Astronomical Society from its formation till the time of his death, except from 1882 to 1889, being re-elected a year ago after that interregnum.

Mr. Scammon was a lawyer by profession, and was recognized by all who knew him as a man of ability, and as a lover of science especially astronomy. He paid for the building of the great tower on which the 18½-inch telescope of the Astronomical Society, was placed. It cost $30,000. He also paid the salary of the director of the Observatory up to the time of the Chicago fire in 1871, and some payments after that date. His services in this noble work were great and are justly an enduring monument to his praise.

Refinements of Modern Instruments. We have received a copy of an address delivered before the Engineer's Society of Western Pennsylvania on the theme, "The Refinements of Modern Instruments and Manipulation," at a recent meeting of the society.

We ought to give our readers an abstract of this valuable paper at least, for it contains much useful information, in regard to mechanical errors in several different astronomical instruments. We promise to do this at an early date, if we do not find space for the whole paper.

Annals of Harvard College Observatory. Part 1, Vol. 21 of the Annals of Harvard College Observatory, and also Vol. 22, are received. The first is the Observations of the New England Meteorological Society for the year 1888, of uniform size of the publications of Harvard College Observatory and containing 105 pages of tables, descriptive matter and twelve charts representing the positions of observing stations, and monthly precipitations.

Vol. 22 contains the meteorological observations made at the summit of Pike's Peak, Colorado, from June 1874 to June 1888. Latitude of position 38° 50′, longitude 105° 2′ W., height 14 134 feet. These observations were made under the direction of the chief signal officer. The main object in this work, on the part of Harvard College Observatory, was to inquire into the meteorological character of stations of great elevation for astronomical observations before undertaking them. It will be remembered that the Boyden Fund, so-called, was established for prosecuting astronomical observations at some station at great elevation above sea level

"*The Chief Discoverers of Comets.*" Under this caption in the March number of THE SIDEREAL MESSENGER is copied from the November number of the *Observatory* a table prepared by Mr. Denning, which contains a few errors, mainly caused by crediting some of the discoverers with comets already known and even expected. Rejecting these, the list, in the order of numbers, stands as follows:

Pons	26
Messrs. Tempel and Barnard, each	13
Brooks	12
Winnecke	9
Mechain and Swift, each	8
Klinkerfues and Borrelly, each	6
Bruhns, DeVico, Brorsen, Donati, Coggia, and Miss Herschel, each	5

This is perhaps a matter of no great consequence, save to the discoverers themselves, who desire to ascertain exactly their standing in this competitive work. LEWIS SWIFT.

Warner Observatory, March 5, 1890.

Vol. II of the Publications of the Astronomical Society of the Pacific is a neat pamphlet of 39 pages. It contains a note on the densities of the planets by Daniel Kirkwood, an article by James E. Keeler, on a new and simple form of electric control for equatorial driving clocks, Arina O. Leuschner's article on the determination of the relation between the exposure-time and the consequent blackening of a photographic film, and number of other brief articles by Professor Holden and other members of the staff of Lick Observatory.

By kindness of F. Folie, Director of the Royal Observatory at Brussels, we have notice of the death of the well-known Astronomer Charles Jean-Baptiste Fievez who was corresponding member of the Royal Academie of Belgium, and astronomer at the Royal Observatory of Brussels. His death occured February 2, 1890.

The Sun-Spots and La Grippe. In the Chicago *Tribune* of Jan. 13, 1890, is an illustrated article under the above title by J. H. Kedzie of Chicago. In it is a comparative table showing the numbers of sun-spots by months for each of the years 1887, 1888 an 1889, also two illustrations of spots, one by Professor Langley, and one from Professor Young's book entitled The Sun. Reference is made in the article to the belief of intelligent men, of a relation between the prevalence of sun-spots and the condition of crops, prices, stocks, peace or war, and public health, including the wide-spread influenza known as La Grippe.

The difficulty that the careful scientist finds in the study of such relations as these is that mere coincidences are not proofs. They only raise a presumption in favor of the assumed cause after a great number of concurring coincidences have been observed. Writers should be careful how they use the principle of induction to establish a relation between sun-spots and disease prevalence, or commercial or political affairs, lest they lead the uninformed into gross errors.

Telescopes for Sale. It may be of interest to our readers to know of the following telescopes for sale:

1. A 4-inch equatorial telescope nearly new; portable mounting; cheap. George Turnham, Meredosia, Ill.
2. A 3-inch astronomical telescope; powers 34 to 64; Tripod mounting. Jacob M. Clark, C. E., 145 Madison Avenue, Elizabeth, N. J.
3. A 5½-inch refracting telescope; circles; driving clock; iron pillar; prism and 5 eye-pieces. Henry Harrison, 14 and 16 Astor Place, New York City.
4. A 5⅓-inch objective in cell, with battery of eye-pieces; also A 2-inch transit instrument in brass pillar; good condition. Daniel Appel, 11 Holyoke Place, Cleveland, Ohio.

Telescopes Wanted. E. P. Frost, Glencoe, Minn., wants a second hand instrument, 6-inch aperture.

J. B. Craton, Council Grove, Kansas, wants a 3 or 4-inch instrument.

U. V. Lawton, Jackson, Mich., wants a good second-hand 4-inch equatorial telescope.

BOOK NOTICES.

FAMILIAR TALKS ON ASTRONOMY, with Chapters on Geography and Navigation. By William Harwar Parker, Author of "Recollections of a Naval Officer," etc., Chicago. Messrs. A. C. McClurg & Co., publishers; 1889; pp. 264. Price $1.

As the title implies, the design of this book is to present the general facts of Astronomy in plain language, and in a more attractive form for the general readers, than that commonly used in the ordinary text-book. These instructive talks are such as a well-informed teacher might give a class of students who have some knowledge of the elements of Astronomy, and who are eager to know more of this delightful branch of study, especially if the instructor will confine himself to the general facts of the science and avoid its *minutiæ* and its techincalities.

On this plan the book gives fourteen talks. The first begins by showing the necessity of *thought* and *meditation* if the student expects to realize much by giving his attention to the reading or study of Astronomy. In this connection the author aptly quotes the sayings of some eminent thinkers while he is talking about reading and thinking. These are examples: Carlyle says: "A man gathers wisdom only from his own sincere exertions and reflections." Paschal says: "All our dignity consists in thought." Gibbon, "The use of our reading is to aid us in thinking." Jefferson, Madison, and Adams were thinking men. When we read their productions we are struck with the originality of their thought. It is true, as Rousseau said: "Naturally man *thinks* but little," but it is also true that "a very small lot of books will serve to nourish a man's mind if he handles them well; and I have known innumerable people whose minds have gone all to ruin by reading carelessly too many books."

This is certainly a fitting introduction, and if the reader heeds it faithfully he will be profited in reading this book.

In the remainder of this first talk the author defines astronomy; speaks of its language; presents the solar system; something of the way ancient astronomers observed; how time is reckoned and the calendar made; of the progress of astronomy, and how the size, shape and motions of the earth are determined. Talks two and three are upon the change of seasons, the obliquity of the ecliptic, the apparent motion of the sun, and the phenomena attending the motion of the earth in its orbit. Talks four and five are in reference to the moon, in which earth-shine, the moon's revolution, and finding the moon's age are noteworthy. Under the last head the author rightly refers to some of the surprising statements of our best English and American writers like the following: Shortly after the sun went down the crescent moon appeared in the east." Dickens in Barnaby Rudge says: "It was a fine dry night, and the light of the young moon, which was then rising, shed around that peace and tranquility which gives to *evening time* its most delicious charm." Captain Maryatt speaks of a *crescent-shaped* and *waning* moon being seen early in the evening. Talks six and seven deal with the sun, noticing its dimensions, its physical characteristics and eclipses. Talk eight is about the planets, and talk nine is a continuation of the same with such added themes as the velocity of light, seasons on other planets, determination of the density and mass of the earth. Talk tenth is about the stars, talk eleventh, time, and talk twelfth is concerning a universal system of time. Talks thirteen and fourteen are upon Nautical Astronomy in which the author has had years of practical experience, and concerning which he speaks so clearly and well that they form an interesting and valuable portion of this book. The publishers' part of this work is neatly done.

THE SCENERY OF THE HEAVENS; A Popular Account of Astronomical Wonders. By J. E. Gore, F. R. A. S., M. R. I. A. With Stellar Photographs and other Drawings. London: Messrs. Roper and Drowley, publishers, 11 Ludgate Hill, E. C. 1890. pp. 320; price, 10*s* 6*d*.

The subject matter of this new book is divided into two parts; the first describing the solar system, and the second the sidereal heavens; the first part is given in seven chapters which present the following topics in order: The Sun, The Moon, The Planets, Comets, Shooting Stars and Meteorites.

The order of the topics in the second part is: Number and Magnitude of the Stars, Double and Binary Stars, Nebulæ and Clusters, Variable and Temporary Stars, The Milky Way and the Visible Universe, and The Astronomy of the Poets. Then follows tables of the Positions of Red Stars, Positions of Binary Stars, and Positions of Variable and Temporary Stars.

The design of this work is to give a popular but exact account of the most interesting facts relating to the planets, comets, meteors, fixed stars and nebulæ, without technical language or the use of mathematical formulæ. The sun is the theme of the first chapter, and the wonderful facts of its size, distance, and attractive power are illustrated in a great variety of ways, some of which are apt and unique, and all are useful and good. The brief description of its physical constitution represents the best and latest views of specialists in this line of study.

The moon is next considered in regard to surface delineation, and a fine

drawing of the lunar walled crater, Plato, by T. C. Elger, 1887, appears in connection with chosen details for study. A single page on the phenomena of a total lunar eclipse, in which the black and bright eclipses are referred to, is very suggestive in regard to matter of fact. No attempt is made to explain the so-called black eclipses. Remarks on the inferior planets are brief, but to the point. An example of this is found under Venus, where the author is speaking of that planet as a morning star, about Christmas time, when it is mistaken for the so-called "Star of Bethlehem," by intelligent and well read people (except in elementary astronomy). We quote a few words. "Whatever the star of the Magi was, one thing is certain, it was not Venus. It seems, indeed, absurd to suppose that the "wise men" of the East should have mistaken a familiar object, like the planet Venus, for a strange apparition. That it was familiar to the ancients we know from the fact that an observation of the planet is found on the Ninevah tablets of date B. C. 684, and it is also mentioned by Hesiod, Homer, Virgil, Martial and Pliny. Indeed it seems impossible to suppose that so conspicuous an object should remain unnoticed for any length of time."

Under the head of superior planets, the author speaks of the force of gravitation on the planet Mars, and in consequence, the possible giant size of its people, the wonderful canals recently discovered there, and the views of prominent observers concerning this phenomenon, the polar snow caps, the ruddy color of its land surface, its two minute satellites, and some of the curious physical facts in consequence of the small mass of each of them.

Such trains of thought as these are to be found in connection with the various topics before named, and the spirit of the whole book is admirable, because it recognizes Almighty God as the Creator of All this wonderful work and gives credit to Him as its Author. We think this is a better way to do than to attempt to glorify what any man may have done in finding out the thoughts of the Creator that probably have waited many ages for the appearance of a human mind that was large enough or natural enough in its powers to perceive them and to understand them.

We have read this book with special interest, and welcome it to a place in our general library.

ELEMENTARY LESSONS IN ASTRONOMY. By J. Norman Lockyer, F. R. S. London: Messrs. Memillan & Co., and New York. 1889, 8vo, pp. 363. Price $1.25.

This book is a new edition of a work bearing the same title that was first published in 1868. It is not to be confounded with the Elements of Astronomy by the same author, which probably has been more commonly used in this country than the book now before us. This revision has the same general appearance as the earlier ones, is somewhat increased in size, and quite largely re-written, having several new cuts, and facts generally brought to date. In the earlier portion of this book Mr. Lockyer makes references to the conclusions which he has reached quite recently in regard to the constitution of the heavenly bodies. These views have been widely published in this country and in Europe, and certainly do not now need further comment. The last edition is materially improved, and is a credit to its distinguished author.

STEPHEN J PERRY S J

THE SIDEREAL MESSENGER

[illegible]

No. 5 [illegible]

PHOTOGRAPHY AND [illegible]

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The photographic [illegible] made, by about twenty [illegible] accompanied by a set of [illegible] purposes. The plates [illegible] that each one will [illegible] of the stars determined [illegible] ness; and this number [illegible] cases. But there will be [illegible] for which additional stars will be needed around [illegible]. Consequently it may be necessary to observe [illegible] about 20,000 stars in addition to the 200,000 [illegible] they are continued to the [illegible] and to observe these 20,000 stars accurately [illegible] must be employed. When [illegible] pleted, it will be necessary to redetermine the stars of the great zones, especially in the northern hemisphere. [illegible] sary accuracy will perhaps be greater than that of [illegible] zones themselves; the mean epoch [illegible] that of the photographic chart will be about 1895.

Hence, if the great zones are repeated about [illegible] the accuracy of the original series, the [illegible] for 1895 will be very advantageously obtained by interpola[illegible]

This repetition of the great zones about 1905, that is to [illegible] between 1900 and 1910, will be, also, I think, [illegible] done by photography. To accomplish this [illegible] about 10,000 plates (2° square) for the whole heaven [illegible] photographic telescope of 13 inches aperture only

[illegible] Astronomy, Williams College, Mass.

STEPHEN J. PERRY S.J.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, NO. 5. MAY, 1890. WHOLE NO. 85

PHOTOGRAPHY AND MERIDIAN OBSERVATION.

TRUMAN HENRY SAFFORD.*

For THE MESSENGER.

The photographic chart of the heavens which is to be made, by about twenty associated observatories, will be accompanied by a set of plates of short exposure for catalogue purposes. The plates will be two degrees square, so that each one will contain on the average about twenty of the stars determined by the great zones now in progress; and this number will be more than sufficient in many cases. But there will be some plates for which additional stars will be needed around the edges. Consequently it may be necessary to observe a catalogue of about 20,000 stars in addition to the 200,000 of the great zones (if as is probable they are continued to the South pole); and to observe these 20,000 stars accurately meridian circles of the largest size must be employed. When the photographic chart is completed, it will be necessary to redetermine the stars of the great zones, especially in the northern hemisphere. The necessary accuracy will perhaps be greater than that of the zones themselves; the mean epoch of the latter is 1875, and that of the photographic chart will be about 1895.

Hence, if the great zones are repeated about 1905, with *twice* the accuracy of the original series, the positions for 1895 will be very advantageously obtained by interpolation.

This repetition of the great zones about 1905, that is to say, between 1900 and 1910, will be, also, I think, most readily done by photography. To accomplish this will require about 10,300 plates (2° square) for the whole heavens. With a photographic telescope of 13 inches aperture only

* Professor of Astronomy, Williams College, Mass.

one minute's exposure to each plate or, with one of 8 inches aperture certainly no more than three minutes' exposure will be required. Allowing as much for time employed in setting the telescope, we shall have six minutes observing time for an average of 15 stars. Or for the 5,000 plates of either hemisphere 500 hours photographic work; which can be readily accomplished in two years by two observatories.

After this has been done, it remains to measure the plate coordinates at leisure and convert them into right ascension and declination. In the complete survey of the heavens down to the 11th and 14th magnitudes, the plates will be regularly arranged. Near the equator each plate will begin 8 minutes farther on in right ascension than the preceding one; or at least some equally systematic order will be employed. But in making short exposures for 9th magnitude stars only it will be better to increase the number of plates by about 30 to 40 per cent, say to 7,000 for each hemisphere, so as to bring the brighter stars near the preceding and following edges, and thus use them for zero points. I have found by trial from the Durchmusterung that in almost all parts of the heavens the stars down to the 8th magnitude inclusive (8.4 or 8.5 of the D. M. scale), are sufficient in number and sufficiently well arranged to make this possible, provided they are very accurately determined.

The conclusion from this is that meridian observations of stars fainter than the 8th magnitude need only be made (for the next few years) for special problems like proper motion and for the zero-points of the great photographic chart: and that those down to the 8th magnitude only (8.4 or 8.5 D. M.) will be the proper work for meridian circles in future. Of such stars there are considerably more than 50,000 in the northern hemisphere; and they should be observed each four times before 1910. This, can easily be done by three meridian circles.

It would seem, then, that up to 1910 there is no very great need of so great masses of meridian observations as would have been required without photography. This latter art will relieve meridian observers of the most irksome part of their duties: the repetition over and over again of the same rather monotonous observations. The only real

problems of this kind for the future will be to keep the catalogues of stars to the eighth magnitude in proper order so as to have accurate places always available; and to observe fainter stars on the meridian only when they are especially interesting.

The comparison stars for comets and asteroids, will often be most readily determined by measuring them from a very few photographic plates along the course of the body,—unless, indeed, eighth magnitude stars are available,—and much time will be saved in the work of completely observing all the stars employed for any particular comet.

In other words, as the photographic process of cataloguing stars becomes more and more systematized many of the difficulties of meridian work will disappear. The zero-points of the plates which will be furnished by direct observation will be more regularly distributed in time; will not so often conflict with each other that the observer must wait years before he can finish his zone; and we shall have fewer star catalogues thirty or forty years in progress. But, on the other hand, the accuracy obtained on the small scale by photograph, an accuracy so great as to compete even with heliometer work, will require corresponding precision in the use of fixed instruments.

There are about one hundred complete sets of first class meridian instruments in active service; a number of these are in need of extensive repairs and reconstruction to make them adequate to the most accurate work.

The subject of systematic differences between results needs especial study at this time; it is hardly worth while to go on repeating observations which have been lately made elsewhere without such study.

And the probable error of the single observation should not now exceed half a second of arc of a great circle in either co-ordinate; nor should any first rate observer be content (for example) with a series of declinations in which discrepancies of 2″ from the mean of 8 or 10 are at all common.

With regard to the plans of future meridian work I have thought a good deal; chiefly for my own purposes. The stars of the 6th magnitude and brighter need now to be observed only for zero-points and for comparisons; otherwise they need discussion of all available materials rather than

re-observation The Greenwich ten-year catalogue just out contains a great many of them, and the lacking ones are now on the Greenwich working list. The stars of the 7th magnitude are very frequently used, for a variety of purposes, both with small instruments and large; a 3-inch transit is large enough for the *accurate* observation of a star of the magnitude 7.4 and a 2-inch for one 6'. 5. In fact the best stars for a 2½-inch transit—the size most commonly used in longitude and latitude work—are precisely those brighter 6th and higher 7th magnitudes whose exact places are hardest to find in the catalogues.

Any meridian observer who wishes to avoid throwing away his labor can be very sure to do a good thing by observing 7th magnitude stars in some definite region with great accuracy; four observations to each object are usually sufficient.

These stars are now of some importance because they are in many cases well determined at an early date. Bradley has few of them; but D'Agelet, Fedorenko, Piazzi, Lalande or Groombridge a great many. Those of the 8th magnitude will especially be needed after 1900.

It will be seen from what I have said in this rather desultory way that photography will practically limit the great mass of future meridian observations (after the plans now in progress are executed) to stars of the eighth magnitude and brighter; that observers should in future confine themselves to making thoroughly good observations, strictly differential in character, unless they are working intelligently upon the fundamental catalogues; that in all probability a good many of the older instruments will be quietly hung up and disused; but that the best and most modern circles (like those of Repsold) will long aid in the solution of important problems. I must reserve for another opportunity the reference to a number of special problems now ripening for solution; but should be glad to correspond with any younger observer who is anxious to make the best of his opportunities in this direction.

STEPHEN J. PERRY, S. J.

C. M. CHARROPPIN, S. J.*

FOR THE MESSENGER.

Stephen Joseph Perry was born in London on August 26, 1833, and received his preparatory education at Gifford Hall School. Early in life he went successively to Douay and Rome to complete his higher studies. Believing himself called by his Creator to work for the salvation of souls, he determined to study for the priesthood. The principal trait of his character was his devotedness to duty, and a remarkable spirit of self-sacrifice which endeared him to all those who knew him. This spirit of self abnegation, this total forgetfulness of self, in order to be useful to his fellow beings, constituted the basis of his many other virtues. One of his familiar mottoes was, "Whatever you do, do it well," and he often repeated: "That a man should throw himself heart and soul into the occupation of the hour." Hence it was that he showed the same earnestness when engaged in a game of foot-ball with the boys of Stonyhurst, as when solving some difficult problem of Solar Physics. He seemed to take as much interest in the conversation of the little boys of the preparatory school, as in the society of the scientific celebrities of the age. His whole character may be summed up in a few words; a learned Jesuit, a great astronomer, yet as simple as a child—one devoted to the duties of his profession and ready to sacrifice his life for the promotion of science.

When scarcely eighteen years of age he studied the institute and constitutions of Ignatius of Loyola. The military plan of the hero of Pampaluna, captivated the mind of the young aspirant, and on the 12th of November, 1853, he entered the novitiate of Stonyhurst, England. After two years' novitiate he went to France for a course of literature, and, after a year, returned to England to complete his philosophy. His superiors soon discovered his great aptitude for Mathematics and his fondness for the most sublime of sciences, Astronomy. He attended the lectures of De Morgan, and in 1858 he occupied the sixth place on the mathematical honors' list of the London University. Soon after

* Professor of Astronomy in the St. Louis University, St. Louis, Mo.

he was sent to Paris for a full course of the higher mathematics. On returning to Stonyhurst in 1862 he was appointed professor of mathematics; after so thorough a training he was found well qualified to take charge of the Observatory.

In September, 1863, he went to study Theology at St. Beuno's College, North Wales, and in 1866 he was ordained priest. Two years later he returned to Stonyhurst, to resume his professorship and to take charge of the Observatory. From this time he never left the college save to take part in some scientific expedition.

In 1866 the Stonhyurst Observatory was selected by the government as one of the principal meteorological stations. Up to that date, the Observatory had been engaged chiefly in meteorological and magnetic observations. In 1874 the Government presented to Fr. Perry a large direct-vision spectroscope made by Browning. Two years later a fine McLean spectroscope was presented by the Meteorological Society. With these two fine instruments Fr. Perry devoted most of his time to the study of Solar Physics.

In addition to this work, regular observations of Jupiter's satellites were made, together with many observations of the spectra of stars. Fr. Perry was a popular lecturer. The people of Liverpool, Wigan, and the neighboring towns will long remember his impressive and interesting lectures, discoursing with ease and earnestness on astronomical topics.

Fr. Perry's labors were not confined to the Observatory alone. In 1868, accompanied by Fr. Sidegreaves, he made a magnetic survey of the west of France. He spent his vacation, the following year, in a like survey of the east of France. Similar surveys occupied his time in Belgium in 1871, in Kerguelen in 1874 and in Nos Vey, Madagascar, in 1882. It was principally on account of his magnetic surveys that Fr. Perry was made Fellow of the Royal Society, on June 4, 1874. Later on he was elected a member of the Council.

In 1870 he took part, for the first time, in an eclipse expedition, his station being Cadiz. In 1874 he was selected by Sir George Airy, Astronomer Royal, as chief of the party destined to observe the transit of Venus at Kerguelen. With

great constancy and energy he overcame many obstacles thrown in his way. The following sentence quoted from his journal was no empty boast: "We were determined that no consideration should make us flinch where the astronomical interests of the expedition were at stake." In 1882 he went to Madagascar for the last transit of Venus. For the eclipse of Aug. 29, 1886, he went to Curacoa in the West Indies; for that of Aug. 19, 1887, to Russia, and last November he sailed for the Islands of Salut, where he observed successfully the eclipse of Dec. 22, 1889, five days before his death.

In an article of limited space it would be impossible to mention, even in a cursory way, all the work undertaken and accomplished by this energetic astronomer. His notes on Jupiter and the red spot, his spectroscopic observations of comets, stars and auroras; his measurement of the chromosphere of the sun, his many papers on solar protuberances and notes on the occultation of stars by the moon, form an immense amount of material, which when thoroughly worked out, will, doubtless, yield very important results.

His labors were appreciated by men of science, and the different learned societies vied with each other to obtain his consent to become an active member of their organizations. As already mentioned he was a Fellow and Member of the Council of the Royal Society; also of the Royal Astronomical Society, and a member of the Royal Meteorological Society, the Physical Society of London, and the President of the Liverpool Astronomical Society. In 1886 he received the honorary degree of Doctor of Science from the Royal University of Ireland, and at various dates he was elected a member of the Accademia del Nuovo Lincei, la Société Scientifique de Bruxelles and la Société Geographique d'Anvers. For several years preceding his death he served on the committee of Solar Physics appointed by the Lords of the Committee of Council on Education; also on the committee for comparing and reducing magnetic observations, appointed by the British Association for the Advancement of Science. He came to America in 1884, on his way to attend the meeting of the British Association held in Canada. Those who met him at Woodstock, Maryland, were favorably impressed

with his genial conversation and unassumed simplicity. In April, 1887, he took part in the International Astrophotography Congress held at Paris.

His last expedition was to the Islands of Salut to observe the eclipse of the 22d of December, 1889. Though attacked by mortal sickness and feeling very ill, he stood at his post on that memorable day, giving quietly his orders and taking, himself, charge of the principal instrument. This was his last work on earth. He was carried to the Comus, and as he saw his last end approaching he gave his instructions to his assistant, Mr. Rooney, S. J., and requested Captain Atchinson to set sail for Demerara, hoping to die among his brethren at Georgetown; but he gave up his soul to his Creator before reaching Demerara, on the 27th of December, 1889. The bishop of the place, the commandant with many attendants, came in a tug-boat to meet the Comus. Fr. Perry had promised the bishop to lecture on the eclipse, on his return. Great then was their grief and disappointment on learning the sad reality. They received into the tug-boat the remains of the illustrious astronomer, and his funeral took place the following day. Fr. Perry died a true martyr of science and the astronomical world will long feel his loss.

A SHORT METHOD OF FORMING THE EQUATION IN CARTESIAN COORDINATES OF AN ELLIPSE PASSING THROUGH FIVE POINTS.

H. H. FURNESS, JR.

For The Messenger.

In answer to the query in The Sidereal Messenger for February: "What is the equation in Cartesian co-ordinates of an ellipse passing through five points $x_1\,y_1$; $x_2\,y_2$; $x_3\,y_3$; $x_4\,y_4$; $x_5\,y_5$, or the simplest manner of forming it?" I beg to offer the following solution:—

If α, β, γ, δ, represent the equations of the sides of a quadrilateral, then

$$\alpha\gamma + k(\beta\delta) = 0$$

is the equation of any conic passing through the four vertices and one other point dependent on the value of k.

Let me now illustrate by means of an example the method of determining this value k:

For instance let it be required to find the equation of a line passing through the point 2, 3 and the intersection of $x - 3y + 2 = 0$ with $3x + y - 7 = 0$

Then $x - 3y + 2 + k\,(3x + y - 7) = 0$ is the equation, and since this is to pass through the point 2, 3, these values viz., $x = 2, y = 3$ must satisfy it. Thus:

$$(2 - 9 + 2) + k\,(6 + 3 - 7) = 0$$
$$-5 + 2k = 0$$
$$k = \frac{5}{2}$$

Then, substituting this value of k in the equation above, we obtain

$$x - 3y + 2 + \frac{5}{2}\,(3x + y - 7) = 0$$

or clearing of fractions and reducing we get

$$17x - y - 31 = 0$$

which is the equation of the line required.

This is precisely the method we shall employ in the following calculation:

The formula for forming the equation of a straight line passing through two points x', y', and x'', y'', is

$$y - y' = \frac{y' - y''}{x' - x''}\,(x - x')$$

Employing this formula for determining the equations of the sides of the quadrilateral, mentioned above, its vertices being $x_1\,y_1$; $x_2\,y_2$; $x_3\,y_3$; $x_4\,y_4$; we obtain

$$y - y_1 = \frac{y_1 - y_2}{x_1 - x_2}\,(x - x_1)$$

or: $\dfrac{y - y_1}{y_1 - y_2} - \dfrac{x - x_1}{x_1 - x_2} = 0$ for the side α

$\dfrac{y - y_3}{y_3 - y_4} - \dfrac{x - x_3}{x_3 - x_4} = 0$ for the side γ

Then $\alpha\gamma = \left\{\dfrac{y - y_1}{y_1 - y_2} - \dfrac{x - x_1}{x_1 - x_2}\right\}\left\{\dfrac{y - y_3}{y_3 - y_4} - \dfrac{x - x_3}{x_3 - x_4}\right\}$

Again:

$\dfrac{y - y_2}{y_2 - y_3} - \dfrac{x - x_2}{x_2 - x_3} = 0$ for the side β

$\dfrac{y - y_4}{y_4 - y_1} - \dfrac{x - x_4}{x_4 - x_1} = 0$ for the side δ

Then:

$$\left\{\frac{y-y_2}{y_2-y_3}-\frac{x-x_2}{x_2-x_3}\right\}\left\{\frac{y-y_4}{y_4-y_1}-\frac{x-x_4}{x_4-x_1}\right\}=\beta\delta$$

And $\alpha\gamma + k\ (\beta\delta)$ will be:

$$\left\{\frac{y-y_1}{y_1-y_2}-\frac{x-x_1}{x_1-x_2}\right\}\left\{\frac{y-y_3}{y_3-y_4}-\frac{x-x_3}{x_3-x_4}\right\}$$

$$+k\left[\left\{\frac{y-y_2}{y_2-y_3}-\frac{x-x_2}{x_2-x_3}\right\}\left\{\frac{y-y_4}{y_4-y_1}-\frac{x-x_4}{x_4-x_1}\right\}\right]=0$$

And this is the equation of a conic passing through these four points and one other dependent on the value of k.

Now since the conic is also to pass through $x_5\ y_5$ we have (when these values for x and y are substituted in the value of k, found from the last equation by transferring the first term over to the other side and dividing by the coefficient of k) the following:

$$k=-\frac{\left\{\frac{y_5-y_1}{y_1-y_2}-\frac{x_5-x_1}{x_1-x_2}\right\}\left\{\frac{y_5-y_3}{y_3-y_4}-\frac{x_5-x_3}{x_3-x_4}\right\}}{\left\{\frac{y_5-y_2}{y_2-y_3}-\frac{x_5-x_2}{x_2-x_3}\right\}\left\{\frac{y_5-y_4}{y_4-y_1}-\frac{x_5-x_4}{x_4-x_1}\right\}}$$

Then substituting this value of k in $\alpha\gamma + k\ (\beta\delta) = 0$ we obtain for our last résult (after clearing of fractions) the following equation:

$$\left\{\frac{y-y_1}{y_1-y_2}-\frac{x-x_1}{x_1-x_2}\right\}\left\{\frac{y-y_3}{y_3-y_4}-\frac{x-x_3}{x_3-x_4}\right\}$$

$$\times\left\{\frac{y_5-y_2}{y_2-y_3}-\frac{x_5-x_2}{x_2-x_3}\right\}\left\{\frac{y_5-y_4}{y_4-y_1}-\frac{x_5-x_4}{x_4-x_1}\right\}$$

$$-\left\{\frac{y-y_2}{y_2-y_3}-\frac{x-x_2}{x_2-x_3}\right\}\left\{\frac{y-y_4}{y_4-y_1}-\frac{x-x_4}{x_4-x_1}\right\}$$

$$\times\left\{\frac{y_5-y_1}{y_1-y_2}-\frac{x_5-x_1}{x_1-x_2}\right\}\left\{\frac{y_5-y_3}{y_3-y_4}-\frac{x_5-x_3}{x_3-x_4}\right\}=0$$

I fear the querist will scarcely feel that I have helped him by presenting such a formidable equation as the simplest, yet such it is.

My thanks are due in great part to Professor E. S. Crawley, of the University of Pennsylvania, for his efficient help and kind supervision of the work.

SUGGESTIONS AS TO A NEW GENERAL CATALOGUE OF STARS.

G. F. CHAMBERS, F. R. A. S.

I have recently been engaged in compiling for my own purpose a catalogue of all the naked-eye stars down to the 5th magnitude, basing my magnitudes in all cases on the Harvard Photometry, the Uranometria Oxoniensis, or the Uranometria Argentina as the case might be. Two points have very forcibly impressed themselves upon me in executing this task: (1) The urgent necessity which exists that astronomers should be provided as soon as may be with a new comprehensive general catalogue of stars; and (2) that the photometric methods put in practice at Harvard and Oxford ought to be applied with the least possible delay to the southern hemisphere.

By a comprehensive general catalogue I mean one modeled in some degree on the B. A. C., but to contain many more stars, or, say all stars down to the seventh magnitude. I believe it is the fashion in some quarters to sneer at the B. A. C., but most unreasonably, as I venture to think. Of course it is forty-five years out of date; of course it is not up to the requirements of the present generation: new methods, and new instruments (and many more of them), are now to be found which were not available when Baily performed his self-allotted task. All these things support my plea for a new catalogue.

The Royal Astronomical Society of London when an infant institution did useful service by publishing a general catalogue of its own: that work paved the way for the B. A. C., and my present suggestion is that the society or its German brother, the Astronomische Gesellschaft, should take in hand forthwith the new general catalogue which is so much wanted. I will make no attempt at this moment to suggest how it should be put together.

With reference to the question of photometric methods, I have been much struck in putting together my catalogue (in which I have given both sets of values) with the remarkable accord everywhere subsisting between the Harvard and Oxford values. This uniform accord seems to me to render the intrinsic value of both very high indeed. And it is this

belief which induces me to urge very strongly the desirability of the whole southern hemisphere being investigated at once with instruments of the like character. This idea, undoubtedly sound in the abstract, finds confirmation in the discrepancies which I have noticed in the magnitudes assigned by Dr. Gould in the Uranometria Argentina to the stars below (say) mag. $5\frac{1}{2}$ which were observed for magnitude by him, as well as at Harvard and Oxford, and I think that the sooner the stars in the southern hemisphere are submitted to exact photometric test by means of suitable photometric instruments the better.—*Astronomische Nachrichten*, No. 2952.

EAST BOURNE, SUSSEX, ENGLAND.

THE REFINEMENT OF MODERN MEASUREMENTS.*

BY J. A. BRASHEAR.

Progress is to-day written upon every page of the world's record; and particularly in the realms of science is it making its unmistakable mark; from thence extending outward to the vast range of correlated studies that go to make up the sum of human knowledge and economics. In astronomy and astronomical engineering, in physics and chemistry, in civil and mineral engineering, in meteorology and in metrology and in mechanics, to say nothing of many other branches of science, do we find progress as the watchword and the theme that excites and moves the human brain to grander and better achievements. It is my pleasure, and an enjoyable privilege, to call the attention of this Society, in my retiring address as your president, to some of these lines of progress in which I have for many years been interested, and which I trust will prove of interest to you. I shall therefore present some thoughts on the refinements of modern measurements.

When Dr. Alfred M. Mayer, of the Stevens Institute, published his splendid papers on the minute measurements of modern science in the *Scientific American* Supplement, some fifteen years ago, it opened the eyes of many of our Ameri-

*From the Transactions of the Engineers' Society of Western Pennsylvania.

can mechanics to the possibilities of a refinement in measurements they had never dreamed of, and I believe those papers, written in such clear and untechnical language, have done an incalculable amount of good to mechanics, who to-day show it by their accurate work, to some of which I shall refer later on.

The day has forever passed when we are willing to say or believe that "three barley-corns make one inch," nor is the advanced mechanic of to-day satisfied with his boxwood rule, graduated to thirty-seconds of an inch, save for the coarsest approximate measurements; but he must have his Brown and Sharp standard graduated to one one-hundredth inches for his *coarse* measures, and his micrometer gauges reading to one one-thousandth for his ordinary work. Even in our iron and steel works, the old-time wire guage, that for a long time held its own, has been displaced by the modern micrometer guage of infinitely greater accuracy.

My esteemed friend, Mr. George M. Bond, has said very appropriately, that "the arm of King Henry the First, or the barley-corn, though possibly furnishing standards good enough for that time, would hardly satisfy the demands of our modern mechanics or tool-makers, who work very often within the limit of one-thousandth of an inch, and even one-tenth of this apparently minute quantity, with surprising unconcern and no less accuracy." Prof. Wm. A. Rogers has also shown that many of our modern mechanics can calliper to one thirty-thousandth of an inch. These, however, are coarse, rough measures when compared with others I shall mention in the course of this paper.

In the domain of astronomical measurements great progress has been made of late years by the use of refined instrumental means, as well as the many methods devised for the elimination of instrumental errors. The divisions of the meridian circle have been brought to astonishing accuracy. I may mention two of the best dividing engines in the world which I have examined through the courtesy of the constructors. Perhaps the most celebrated is that of the Repsolds in Hamburg. This wonderful engine has come through three generations of celebrated mechanicians, each one adding to its accuracy until now it seems to have

reached the limit of human capability; in other words, as perfect as the environments of temperature, and other factors over which human hands and brains have no control, will allow it to be brought. The maximum error of the best circles divided by this engine equals 1.17″. This engine is not automatic, but each line is set by from one to five microscopes, and the division traced by hand.

The other engine is that constructed by Messrs. Fauth & Co., of Washington, D. C., and is entirely automatic in its work. It is a fine piece of mechanical construction, and does honor to the constructors, and when compared with the original dividing engine of Ramsden, which I have examined, and which was a marvellous piece of work for its time, it tells unmistakably the advance of modern mechanical appliances in that direction. The mean error of a circle recently divided on this engine for the Cincinnati Observatory, as determined by Prof. Porter, is not greater than 1.0″. The Heliometer is now playing a most important part in accurate astronomical measurements, and the work of Dr. Elkin of the Yale University Observatory, and that of Dr. Gill at the Cape of Good Hope, with this instrument, will, in all probability, give us a nearer approach to the absolute solar parallax than has yet been obtained; and this may be appreciated when you remember that the uncertainty lies in the third decimal place of seconds of arc, a quantity altogether inappreciable to ordinary mortals.

This instrument has been largely used in a determination of the parallax of the "fixed" stars, and such measurements are perhaps the most refined in the whole realm of astronomical studies, as no star has yet been found with a parallax greater than 0.9 seconds of arc, and most of those nearest to us are not greater than half that quantity. When it is considered that personal and instrumental errors must be eliminated for a period extending over one-half the earth's annual revolution, it is not to be wondered that in many cases the measure came out sometimes a plus—sometimes a minus quantity, with instruments used for the purpose before the Heliometer was brought into requisition. I should like to describe this instrument, which indeed has been wrongly named, but time will not permit.

The astronomical camera is also adding largely to accur-

ate astronomical measurements. It was thought at first that the shrinking of the film on the negatives would make stellar distances an uncertain factor, but no less an authority than Dr. Elkin asserts that the photographic charts of the Pleiades are as accurate for refined measurements as the stars themselves by the use of the Heliometer, and whereas many of these stellar measurements have to be carried on for years under the most trying conditions, by the photographic method, a few hours will photograph all the stars of a group, or cluster, down to the sixteenth magnitude, and then the plate may be leisurely studied and measured in the laboratory without hindrance from cloud, bad definition or the thousand and one difficulties the astronomer meets in endeavoring to reach his ideal. I could dwell here for all the time at my disposal, but I dare not.

Time measurements in astronomical Observatories have reached wonderful accuracy. When our big bell tolls the quarert hours of the dial, we pull out our watches and are satisfied if we are within quarter of a minute. Fortunately, our astronomer at the Allegheny Observatory is not so easily satisfied. If the stars will but shine, he is not content if the error be sixty times less, *i. e.*—a quarter of a second; and I recently saw the figures for several days' "time" work, where the errors were not greater than three one-hundredths of a second. We all know the great benefit of this time, transmitted to our railroad centers, and if human ingenuity could but have the trains keep time with the stars, we should never have the paradoxical phenomenon of two trains endeavoring to occupy the same track at the same time.

A recent instrument for accurate astronomical measurement, invented by Prof. S. P. Langley, and constructed at our works, is named by the inventor an occulting eye piece. Experiments have shown that the time of the occultation of a star may be readily determined with this instrument within one-twentieth of a second, and with experience the time may possibly be determined within one-fiftieth of a second, and this perfectly free from the element of personal equation.

In the construction of astronomical instruments greater and greater perfection is being reached in every decade, and

the time has passed when the astronomical engineer is satisfied with "cut and try" methods as of old The mathematician stands by him ever ready with the magic plus and minus, to urge him on to higher attainments, to reach as near as possible to the demands of nature's unalterable laws. The object-glass of the telescope, that marvellous eye that peers into the fathomless depths of stellar space, is now brought to most wonderful perfection, and has almost reached the limit of human possibilities. The refinement of the measurements of its curves may be slightly comprehended by the uninitiated, when I say from personal knowledge and experience that the rubbing of a surface for a few seconds of time with the tip of the finger and the finest of polishing material, may ruin the accurate performance of the glass The measurements of the curves sometimes reach to the sixth decimal place, and the artist of to-day can determine so minute a quantity with great precision and certainty. In modern investigations of the object-glass of the telescope, no one has done so much to bring it up to the highest standard of perfection as Dr. Charles S. Hastings of Yale University. He has just completed some of the most refined studies in this line that have ever been made, and, perhaps, since the days of Gauss, no such advancement in mathematical dioptrics has been made, which, carried out experimentally, is now yielding most remarkable results.

In the realms of physical investigation and apparatus, great accuracy has been reached in the past few years Let me mention one branch in which I have taken an humble part, namely, the production of optical surfaces and the ruling thereon of those marvellous diffraction gratings which have so greatly advanced the study of spectrum analysis. I can well remember when Nobert, of Pomerania, produced his first test-bands for the microscope, and when he produced his first diffraction grating, which, in its entire ruled surface, was but two centimeters square. To-day we are producing surfaces fifteen centimeters square, in which the error of curvature or flatness, as the case may be, is less than one two-hundred-thousandths of an inch; and on which Prof. Rowland has ruled one hundred and ten thousand lines with such precision that the error between any two of the lines is probably less than one three-millionths of

an inch. With this instrument of research physicists have boldly entered into new and untrodden regions of nature, and are from time to time uncovering her hidden wealth to enrich the storehouse of earthly knowledge. I present for your inspection the wonderful map of the spectrum of the sun, which has been so recently placed in our possession by Professor Rowland. Here, spread before you, is the result produced by the use of the concave diffraction grating, untouched by the hand of man. Here, in the red end of the spectrum, you see the marvellous B group, never before photographed as you see it now. Here you see the great C line and here the D lines, one of which is plainly double, while you see thirteen lines between the D lines. I can well remember when the instrument that would show the one nickel line between the D lines was considered a marvellous piece of work. Passing over the thousands upon thousands of lines between the D lines and the H line, we stop for a moment to examine between the H and K lines. Here is Angstrom's celebrated map of the solar spectrum. If you will examine it you will see he places three lines between H and K. In this photographic chart before you, I count one hundred and twenty-one lines between the H and K. But here Angstrom stops with his chart, because the human eye fails to see satisfactorily much farther; but on this photographic chart we have, beyond the H K group, more lines than in the whole of Angstrom's map, as you see extending about thirteen feet on the photographic chart beyond that which is visible to the human eye, and containing thousands of lines. The value in wave lengths on these charts is given within one one-hundred-thousandth of its true position.

All this has been brought about by work of the highest character requiring refined measurements and manipulation, of which our forefathers knew practically nothing. But the end is not yet. Refined as these measures may be, yet finer and more critical are being done, and we are now constructing a machine called by its inventor, Professor Albert Michaelson, an "Interferential Refractometer," in which this same phenomena of interference is made the basis of measurement which lies close to the border land of human possibilities.

You are all aware that the various enlightened and civilized nations have standards of weight and measure that

have slowly been evolved from the cubit, the span, the finger length and the barleycorn, if you please. Intimately associated with the evolution of standards of measurements are the names of Kater, Bailey, Bessel, Airy, Bird, Troughton, Babbage, Ramsden, Repsold and many others I could name; but in our modern work perhaps few men have done more than our own Professor William A. Rogers, whom some of you know personally. I here submit to you one of his decimetre standards in which we have included standards for the centimetre, millimetre and hundredths of millimeters.

But, as I said, nations have their standards. On what are they based? The French metre is presumed to be one ten-millionth of the earth's quadrant, the English yard evolved from the barley-corn, etc., but the measurements of precision in our day demand an indestructable, absolute and unalterable basis for our standards, so that if they all be destroyed the original is still available. Professor Michaelson has chosen a wave-length of sodium light as the basis for a new standard, a something that will remain forever of the same absolute linear value, or at least so long as the solar system floats in the luminiferous ether that, so far as we know, pervades the entire universe. Now, a wave-length of sodium light is, roughly speaking, about one forty-two-thousandths of an inch long; or better, five thousand eight hundred and ninety ten-millionths of a millimeter. Now, as this is an appreciable figure, it is evident that any method proposed to measure its *absolute* value must be of the highest accuracy. The method devised by Professor Michaelson in the refractometre has certainly brought the work to marvellous perfection; for in a paper read by him at the Cleveland meeting of the American Association, he showed that the error was not greater than one part in two millions, and possibly would be made not greater than one in ten millions. Gentlemen, can you appreciate such a quantity? Yet here is a physicist, with a high ideal of perfection, taking the pulsations that are sent earthward by the sun, and by methods within the reach of human skill, actually recording them upon a standard bar immersed in a freezing mixture and giving us a universal standard based upon the absolute value of a wave-length of light. You may appreciate some of the niceties in the construction of this interferential re-

fractometer when I tell you that in making some of the optical surfaces for use with it, Professor Michaelson demands an accuracy closely bordering on one millionth of an inch.

With the new instrument Professor Michaelson proposes to carry out advanced experiments on studying the coefficients of expansion of standards, etc., the coefficients of elasticity, and critical measurements of the indices of refraction of various substances. But I must not dwell here, though the theme is as enchanting as Fairy Land. Nations have joined together for the production of standards of weights and measures, and but recently our government has received its new set, of which I hope we shall have a full description in the lecture we are to enjoy from Professor Mendenhall on this very subject. It may be of interest to you, however, to mention the fact that Professor Wm. A. Rogers, formerly of Harvard Observatory, has devoted the better part of his life in studying the errors of standards in use in this country and in Europe, as well as producing some of the best work in this line that has ever yet been done. Perhaps no living man has worked so earnestly upon his hobby. For years he got out of his bed at five o'clock every morning to compare his bars of bronze, steel, copper and glass, at an hour when they had swung through their occillation or temperature changes so as to be able to determine the absolute value of their coefficient of expansion, as well as to learn whether the material from which the standards were made passed through slow molecular changes or not. Among many important facts he has brought to light, is that of the equable expansion of metals, etc., *i. e.*, that the expansion is equal for each degree within a range from zero to the boiling point, so that it is now only necessary to know the coefficient for one degree, and add or subtract from the standard temperature at which the bar was normal. In the production and ruling of these standards there are so many factors that come as hindrances to perfect work, that Professor Rogers must have added to his virtues that of patience to a very large degree. I have no doubt some of our members call to mind his paper, read in Pittsburgh some four or five years ago, before the National Association of Mechanical Engineers, on "A Solution of the Perfect Screw Prob'

The great Whitworth said, "a perfect screw

made," and perhaps he was correct, but Professor Rogers has brought its solution about as close as any living man, except, perhaps, Professor Rowland, who indeed makes the best screw possible by mechanical means, and then by studying its errors, eliminates them by one of the most simple, yet beautiful devices, ever applied to the solution of so important a problem Those of you who may be interested in this matter, will find a most excellent article on the subject by Professor Rowland under the title, "Screw," in the ninth edition of the *Encyclopædia Britannica*. I here take the liberty to show you a screw made under the supervision of Professor Rogers in some of his earlier work. Its linear error is not greater than 0.00005 of an inch, but it has unfortunately a periodic error of drunkenness, that makes it useless for the purpose for which it was designed, though for purposes where it can be used in whole revolutions, it is perhaps equal to any ever made It cost the labor of two of the best workmen of the Waltham Watch Tool Co., for 425 hours, at $1 per hour, so that it cost almost half its weight in gold.

One of the most delicate methods of studying a so-called perfect screw is to rule a diffraction grating by the aid of a diamond moved by the screw. If there are errors of drunkenness as in this screw, the interference is so irregular that no lines can be seen in the spectrum of the line from the grating so ruled. If it is more nearly perfect, the imperfection is made known by false lines or ghosts in the spectrum, and like Banquo's, they will not down until the errors of the screw are eliminated. There are many other methods of determining errors in the run of a screw, some of them of high value, and it is with considerable pride that I say our American machine shops are taking advantage of them to produce better and better work.

(TO BE CONTINUED.)

ASTRONOMICAL SOCIETY OF THE PACIFIC.

MARCH, 29, 1890.

By invitation the Annual Meeting was held in the rooms of the California Academy of Sciences, the President, E. S. Holden, presiding.

The minutes of the last meeting were read and approved. After thanking the Academy of Sciences for the use of their large rooms the chair called upon the Committee on Nominations to report. The Committee submitted the following ticket of eleven for Board of Directors and a Committee of three on Publication:

For Board of Directors—E. S. Holden, Frank Soule, J. M. Schaeberle, Charles Burckhalter, Wm. Alvord, Wm. M. Pierson, E. J. Molera, C. M. Grant, C. B. Hill, J. H. Wythe, F. R. Ziel.

For Publication Committee—E. S. Holden, J. E. Keeler, C. G. Yale.

The polls were declared open until 9 o'clock and Messrs. E. H. McConnell and F. R. Ziel appointed tellers. The election resulted in the ticket being unanimously elected.

The following were elected to membership: Messrs. Grieg, Maw and Davidson, were made life members; Alanson H. Phelps, H. C. Lion, H. T. Bestor, A. M. Hickox, Harvey Durbrow, Mrs. H. A. Harland and W. E. Hess, San Francisco; George Gleason, Berkeley, Cal.; Miss M. E. Chase, Santa Rosa, Cal.; A. W. Craig, Oakland, Cal.; Mrs. Harriet Wright, Denver, Colorado; D. Patin, Philadelphia; J. J. Malowney, Hebron, Neb.; Arthur M. Hussey, Ann Arbor, Mich.; Andrew Greig, Tay Port, Scotland; Miss Dorothea Klumpke, Paris, France; O. A. H. Pihl, Christiania, Norway; A. Stanley Williams, F. R. A. S., Brighton, England; W. H. Maw, F. R. A. S., London, England; Herbert Sadler, F. R. A. S., London, England; John Tebbutt, F. R. A. S., New South Wales; J. Ewell Davidson, Queensland, Australia; Miss Lassell, Maidenhead, England.

The Secretaries announced the receipt of seventy-five presents and publications and the thanks of the Society were returned to the donors.

Treasurer E. J. Molera read his Annual Report which showed the following results for the first year's work of the Society.

Receipts from Dues	$2,145.00
Receipts from Publications	2.00
Received from Alexander Montgomery for Library Fund	2,500.00
Received from Joseph A. Donohoe for Comet Medal Fund	500.00
Total Receipts	$5,147.00

Expenditures for Publications and other expenses	$1,026.25
Cash in Bank (General Fund)	1,120.75
Cash in Savings bank	3,000.00

$1,000 of the Library Fund is to be expended in the purchase of a library for the use of the members.

A communication was read from Messrs. Hausman and Jones, proposing the establishing of an Observatory in San Francisco for the use of members of the Society. The communication was referred to a committee to report at the next meeting.

Mr. J. M. Schaeberle presented a paper entitled "A Mechanical Theory of the Solar Corona." It stated that his investigations seemed to prove conclusively that the solar corona is caused by light emitted and reflected from streams of matter ejected from the sun by forces which in general act along lines normal to the surface of the sun; these forces are most active near the center of each sun-spot zone.

Owing to the rotation of the sun, the streams of matter will not lie along normals, since the angular velocity of different portions of the stream grows less as the distance from the sun increases; in other words, the streams are double curvature. Each individual particle of the stream, however, describes a portion of a conic section, which is a very elongated ellipse so long as the initial velocity is less than 383 miles per second (assuming that the sun's atmosphere, as shown by various observations, is exceedingly rare).

The variations in the type of the corona admit of an exceedingly simple explanation, being due to nothing more than the change in the position of the observer with reference to the plane of the sun's equator. Accordingly, as the observer is above, below, or in the plane of the sun's equator, the perspective overlapping and interlacing of the two sets of streamers cause the observed apparent variations in the type of the corona.

Mr. Schaeberle then exhibited a model, in which the sun is represented by a ball about an inch in diameter, from which radiate a number of needles, to represent the streams of matter. All these needles are contained between two zones corresponding to $\pm$ 30° of latitude. The longer ones are most numerous near the middle of each zone, and slightly more inclined to the normal than the shorter ones, in order

that the more distant portions of the needles (representing the outgoing streams) shall have directions roughly the same as required by physical laws. Eight photographs of the model, representing the various types of the corona, were also shown.

When the model is placed in a beam of parallel rays and its shadow allowed to fall upon a screen, the slightest change in the position of the model produces an entirely new image.

Mr. Schaeberle stated that he had thus far been unable to find a single observed phenomenon which could not be accounted for by this mechanical theory.

A discussion of the theory and a comparison showing the remarkable agreement with observation will appear in the report of the eclipse of December 21, 1889.

Mr. Holden gave an account of the photometric determinations of the actinic brightness of the Corona. Two of the plates taken by Mr. Burnham and two taken by Mr. Schaeberle were standardized. A preliminary reduction of these plates show that the brightness of the corona and sky, as measured directly from the plates, will substantially reproduce the results obtained by Mr. W. H. Pickering at the eclipse of 1886 in Grenada. That is, the brightness of the corona, as measured directly from the plates, will be only about *40 per cent* of that obtained from Mr. Barnard's plates of the California eclipse of January 1, 1889. Mr. Pickering's plates of 1886 were not developed for several months after the eclipse, and when developed the films were found to have deteriorated. The Cayenne plates showed also a great deterioration, due to dampness, though they were developed immediately after exposure. Precautions were, however, taken before the eclipse, which will possibly enable us to give a numerical estimate of the amount of change. Besides the eclipse plates ten others (A, B, C, D, E, F, G, H, I, J), were standardized by Mr. Barnard at the Lick Observatory, on September 24, 1889. A, B, C, D were taken to the eclipse and E, F, G, H, I, J remained at the Lick Observatory. I and J were developed on September 24, 1889, immediately after exposure. A and B were developed at Cayenne on December 22, 1889. E and F were developed at the Lick Observatory on the same day.

C and D were returned undeveloped to the Lick Observatory (arriving there March 5, 1890). G and H (still undeveloped) and C and D were then re-standardized by Mr. Barnard March 16th, and all four were developed together, March 17. Thus a complete history of the changes of these plates is available; and it is possible that a numerical factor can be obtained by which to multiply the measures of brightness obtained directly from the plates taken at Cayenne to obtain the results which they would have given had the eclipse occurred at Mt. Hamilton.

The practical result of this interesting experiment is to show that plates which are to be exposed in a damp climate should be hermetically sealed until they are exposed and again sealed immediately afterwards. The agreement between the results of Mr. Pickering's measures and those of December, 1889, shows that both are erroneous. The measures on the plates of January, 1889, are to be taken as correct, at least for the present.

Papers were also presented by Dr. H. Kreutz, of Kiel, on *Die Astronomische Gessellschaft*; by Mr. A. O. Leuschner, on The Orbit of μ^1 Hercules; by Professor Daniel Kirkwood, on The Similarity of Certain Asteroid Orbits. The meeting then adjourned.

After the adjournment of the regular meeting, a meeting of the Board of Directors was held to elect officers. Professor Holden was re-elected President; Messrs. Pierson, Soule, and Wythe, Vice-Presidents; Messrs. Schaeberle and Burckhalter, Secretaries, and E. J. Molera, Treasurer.

The next meeting of the Society will be held at the Lick Observatory, May 31, 1890.

CHARLES BURCKHALTER, Secretary.

THE METEORIC THEORY OF COMETS.

W. H. S. MONCK.

For THE MESSENGER.

As the meteoric theory of comets forms the ground-work of Mr. Lockyer's new theory of the stars and has, moreover, been accepted by many astronomers who are not prepared to accept Mr. Lockyer's hypothesis in its full extent, some further remarks on the subject may not be out of place.

I have already noticed that only four comets have hitherto been connected with meteor-showers and conversely only four meteor-showers have been connected with comets. This fact at once shows the breadth of the jump which we must take in order to reach their identity. To take a parallel case, Saturn's rings are generally believed to consist of collections of meteors; but are we thence to conclude that Saturn consists of meteors and then to extend this conclusion to all other planets and satellites? It might be indeed that only four comets have come close enough to the earth to bring us into contact with their meteor-trains. But if this be so, whence come the numerous meteor-trains which have not been connected with any comet? Moreover there are strong reasons for believing that we have come near enough to a number of comets to encounter their meteor-trains if they possessed such appendages. Lexell's comet (a brighter one than the trained comet of Biela) approached within 1,400,000 miles of the earth in 1770 and from the very small inclination of its orbit to the ecliptic, Lexellian meteors might have been expected to be met with, even at a considerable distance from the node. I do not, however, find any remarkable meteor-shower recorded on that occasion. The comet of 837, according to Mr. Chambers, remained for four days within less than 4,000,000 miles of the earth. This was a great comet and such a prodigy as a shower of falling stars in connection with it could hardly fail to have been recorded. The great comet of 1861, which Sir John Herschel regarded as the finest of the century, approached within a moderate distance of us, and it is believed that we actually passed through its tail. This last is an important element in the opinion of Mr. Lockyer, who says: "Meteorites are formed by condensation of vapors thrown off by collisions. The small particles increase by fusion brought about again by collisions and this increase may go on until the meteorites may be large enough to be smashed by collisions," (*Nature*, Vol. XXXVII., p. 56). Several other comets mentioned by Hind have made a close approach to the earth, among which I may refer to one of those of 1826. In none of these cases was a great star-shower observed.

It may be remarked that the four comets which have been

connected with meteor showers are all periodic, the longest period being 415 years. The fact may not be unimportant in connection with the theory of ejection advocated by the late Mr. Proctor. The recent instance of Krakatoa may suffice to show us that the increase of volcanic power which would be necessary to eject both stones and gases into space is less than might have been anticipated. Transfer Krakatoa to one of the asteroids, or even to the moon, and the ejection would become actual. Mr. Proctor indeed spoke of the ejection as taking place when the planet was "in the sun-like state," but it is evident that it might also occur after it had considerably cooled down. Now, while an ejection from the sun, or a sun-like body, might be purely gaseous, an ejection from a rapidly-cooling body would probably be partly solid partly liquid, and partly gaseous, like the products of our terrestrial volcanoes. The gaseous eject might thus form the comet, and the solid (or solidified) eject the attendant flight of meteors. For this origin of the four meteor comets, indeed, we must suppose two Ultra-Neptunean planets, but their existence is not unlikely on other grounds. Of the other two the Andromeda meteors and Biela's comet may have arisen in ejection from Jupiter and the Leonid meteors with their comet in ejection from Uranus

That the connection between the comet and the meteors is more likely to be of this character than to be one of absolute identity is suggested by various circumstances. The August or Perseid meteors are met with every year with but little difference in richness. Mr. Denning has seen them as early as the 8th of July and as late as the 25th of August. As the orbit of the corresponding comet is inclined to the ecliptic at an angle of over 66°, it is plain that at these dates (especially at the former) the earth is at a very considerable distance from any part of the comet's orbit; but of course a shower of stones, originating in a grand volcanic convulsion, might be very much scattered and cover a much wider space than the gaseous eject which originated at the same time. There is a curious shifting in the radiant of this meteor-shower noticed by Mr. Denning, the mathematical theory of which it would be very desirable to explain. Mr Chambers (I do not know on what authority), sets down

the probable period of this meteor-shower at 108 years, while for the corresponding comet a period of 123 years has been computed. Again, the great meteor-shower of April 4th, 1095, was most probably a shower of Lyrids, whereas a period of 415 years, (as computed), for the corresponding comet would lead us back to 1030. The great meteor, (followed by a number of smaller ones), recorded in the Chinese annals in March, B. C. 74, also looks like a Lyrid, and as the shower is not often limited to a single year the period agrees very fairly with that indicated by the shower of 1095, but is several years shorter than that of the comet. It is hardly necessary to say that if the meteors followed the exact track of the comet we should not meet them at all, for there is no known comet whose orbit intersects that of the earth. The node is, in all cases, at some distance from the earth's track; but there can be no doubt that the meteors are often found at a considerable distance from the track of the comet, as well as at a very great distance from the comet itself.

Then, will the hypothesis that comets consist of clouds of meteors explain all the peculiarities which comets exhibit? Mr. Lockyer admits the contrary. "When a meteor-swarm approaches the sun," he says, "the whole region of space occupied by the meteorites (estimated by Prof. Newton in the case of Biela's comet to have been thirty miles apart) gives us the same spectrum, and further, it is given by at all events part of the tail which, in the comet of 1680, was calculated to be 60,000,000 miles in length. The illumination, therefore, must be electrical and possibly connected with the electric repulsion of the vapors away from the sun: hence, it is not dependent wholly on collisions" (*Nature*, Vol. XXXVII, p. 60): to which I may add that the meteoric theory affords no explanation of this electric repulsion. As Mr. Lockyer does not derive the entire light of the comets from collisions of meteorites and does not state how much of it comes from this source, it is not very easy to agree with him here. But let us remember that the individual meteorites are of small size and that they are moving in similar orbits with nearly equal velocities, so that even if we placed them thirty yards (instead of thirty miles) apart, the chances against any collision would be very great. More-

over, if a collision occurred, it would probably be a mere graze which would develop very little light or heat and produce no perceptible amount of vapor. I may refer to Saturn's rings in confirmation of this. No comet, I believe, has ever been seen at the distance of Saturn, though the dimensions are often greater than those of Saturn's rings. Consequently the interspaces must be much larger, relatively to the space occupied by the meteors, in the case of the comet than of the rings. Hence, collisions ought to be much more frequent in Saturn's rings than in any comet. But though Mr. Lockyer thought he had detected bright lines in Saturn's ring indicating such collisions, Dr. Huggins, on examining them with a more powerful instrument, could detect nothing but reflected light.

The theory that comets consist of clouds of meteors has been supposed to explain their transparency and their small mass. I do not think it explains either. If a comet either consists of a collection of solid bodies with void interspaces, or of a collection of solid bodies surrounded by gases or vapors caused by collisions, the mass (when the large volume of the comet is considered), must be considerable. In the former case the comet would not be visible at the distance at which we see it if the mass was very minute; in the latter case meteors moving nearly in the same direction and with nearly the same velocity could not generate this amount of vapor by collisions unless they were thickly packed together. It is, moreover, almost impossible that a collection of solid bodies should be visible at a distance and yet transparent. It is useless to argue, as Professor Tait does, that a single meteor at the distance of a comet could not hide a distant star. He might as well contend that because one rain-drop or one particle of dust could not hide a distant object, a heavy shower or a cloud of dust could not do so. Or perhaps a better analogy is that of a light haze which enables us to see objects at the distance of a mile almost as well as ever but hides a distant mountain-range which is visible on a clear day. But we can see stars through hundreds or even thousands of miles of comet, whatever the comet may be composed of; and it appears to me that the mass will be less and the transparency greater if we assume it to be purely gaseous than if we suppose it

to be made up in great part of solid, though small, bodies. The gaseous theory, too, is I think more in conformity with Mr. Lockyer's explanation, (previously given by me), of the retardation of Encke's comet. A shower of meteors fired into an approaching mass of gas would, I believe, retard its progress, but if fired into an approaching cloud of meteors it would strike a few colliding meteors out of the general mass, but those which escaped the collision would move on unimpeded. There would be a few killed and wounded, but the progress of the advancing column would not be delayed. The force of these arguments would be considerably strengthened if the latest results attained in certain departments of Astronomy could be relied on as absolutely correct. According to the latest estimate the mass of Saturn's rings is about double that of the planet Mercury. If the mass of Encke's comet at all approached this figure, its effects on the motion of Mercury would be very perceptible. But if it does not approach it, why are the collisions so numerous in the case of the comet and so few in the case of the rings? Again, Saturn's rings (except perhaps the inner gauze-ring), are not transparent, whereas it is computed that Arcturus was seen through 90,000 miles of Donati's comet with hardly diminished splendor. (If such a chance should again occur I hope the opportunity of making accurate photometric measures of the star will not be lost). The inference seems plain that the rings of Saturn are more than 1,000 times as dense as Donati's comet at the point where it crossed between us and Arcturus; but as regards collisions, the figures must (on the meteoric theory) be reversed.

I am not objecting to the Meteoric Hypothesis as a working hypothesis. As such it is, I think, entitled to stand beside the older Nebular Hypothesis; but we have made little progress toward establishing the truth of either. I am rather disposed to think that matter has always existed in its three conditions, the solid, the liquid and the gaseous; and that while some existing solids have been formed by the condensation of gases and some existing gases have been produced by the collision of solids, the relative proportions in the Universe have not been largely altered. At all events, I do not think the spectroscope will ever afford a crucial test between the Nebular and the Meteoric Hypotheses. It can

show, no doubt, that the body examined is partly solid and partly gaseous; and repeated observations of the same object may show whether the solid or the gaseous portion is on the increase. But I doubt if the spectroscope will ever distinguish between a large solid surrounded by a gaseous envelope and a number of small solids with the interspaces filled with gas. If I am correct in this view, Mr. Lockyer's spectroscopic observations have no bearing on his hypothesis. They may no doubt show that the heavenly bodies consist of the same chemical elements as the meteorites and ærolites which have fallen to the earth; but speaking generally this has long been known. Celestial bodies, indeed, afford indications of a small number of elements not hitherto discovered either in terrestrial bodies or meteorites; but supposing these exceptions removed, the question between the Nebular and the Meteorite Hypotheses would remain exactly where it was before The results of Professor Newton's investigation, moreover, seem to indicate that all the meteorites, on whose spectra Mr. Lockyer experimented, had their origin within the limits of the solar system Meteors coming from inter-stellar space would probably arrive with such high velocities as to insure their being dissipated in the air at a considerable altitude. The Meteoric Hypothesis must therefore be expounded generally and without any special reference to spectroscope results before it can claim general acceptance, unless, indeed, the spectroscope should hereafter enable us to distinguish between the light of a single large body and that of a number of small ones I am, however, concerned only with that theory as regards comets, and with regard to these bodies I think it has not been proved.

Equations for an Ellipse through Five Given Points. "What is the equation, in Cartesian co-ordinates, of an ellipse passing through five points, x_1, y_1; x_2, y_2; x_3, y_3; x_4, y_4; x_5, y_5; or the simplest way of forming it?"

The five constants, a, b, c, d, e, from the five simple equations containing them and the co-ordinates of the given points, namely:

$$y_1^2 + ax_1y_1 + bx_1^2 + cy_1 + dx_1 + e = 0$$
$$y_2^2 + ax_2y_2 + bx_2^2 + cy_2 + dx_2 + e = 0$$
$$y_3^2 + ax_3y_3 + bx_3^2 + cy_3 + dx_3 + e = 0$$
$$y_4^2 + ax_4y_4 + bx_4^2 + cy_4 + dx_4 + e = 0$$
$$y_5^2 + ax_5y_5 + bx_5^2 + cy_5 + dx_5 + e = 0$$

Substituted in the equation

$$y^2 + axy + bx^2 + cy + dx + e = 0$$

gives the equation of the conic section passing through the five points, x_1, y_1; x_2, y_2, etc. The co-ordinates of its center are $\frac{ac + 2d}{4b - a^2}$ and $\frac{ad - 2bc}{4b - a^2}$.

R. J. ADCOCK.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at greatest elongation east from the sun on May 5, and will be in a very favorable position for observation in the evening during the first half of the month. It will be visible to the naked eye for several days, between 8 and 9 P. M., in the west, not far from Venus. On May 29 Mercury will be at inferior conjunction, and so will not be visible during the latter part of this month or the first of next.

Venus is a conspicuous object in the west in the early evening. Reports have come to us of persons who have been able to see Venus in midday, but we have so far been unsuccessful in the attempt. Venus and Mercury will be in conjunction May 10, at 1 A. M., Mercury being 1° 45′ north of Venus. They will be near each other for several days. The red star Aldebaran will also be in the same vicinity.

Mars will be at opposition May 27. Its distance from the Earth at that time will be about 45,000,000 miles. During the opposition of 1892 the least distance will be about 35,000,000 miles, a little less than that at the opposition of 1877, when the satellites were discovered. At both the oppositions, of 1890 and 1892, it will be in extreme southern declination, for the planet, so that the best observations may be had in the southern hemisphere. The diameter of Mars' disk on May 27 will be 20.5″. He will be found in Scorpio, a little northeast of the red star, Antares, during the first part of the month, and northwest of that star at the end of the month.

Jupiter may be seen in the southeast in the morning among the faint stars of Capricorn.

Saturn will be at quadrature, 90° east from the sun, May 18. Probably most of our readers have noticed the retrograde or westward motion of Saturn during the last few months. He will now begin to move eastward, increasing the distance between himself and the stars of the Sickle.

Uranus may be found in the east in the evening in the Constellation of Virgo, about 4° northeast of Spica. He is in good position for observation.

Neptune will be in conjunction with the sun May 25, and so cannot be seen during this month.

MERCURY.

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25	4 38.6	+21 11	4 51 A.M.	12 25.4 P.M.	8 00 P.M.
June 5	4 16.9	+17 39	4 04 "	11 20.5 A.M.	6 37 "
15	4 15.6	+17 01	3 26 "	10 39.9 A.M.	5 53 "

VENUS.

May 25	5 54.7	+24 40	5 50 A.M.	1 41.4 P.M.	9 32 P.M.
June 5	6 53.3	+24 26	6 07 "	1 56.6 "	9 47 "
15	7 45.6	+23 00	6 27 "	2 09.2 "	9 52 "

MARS.

May 25	16 19.0	−23 05	7 39 P.M.	12 04.1 A.M.	4 29 P.M.
June 5	16 02.8	−22 58	6 39 "	11 04.5 P.M.	3 30 A.M.
15	15 50.1	−22 47	5 46 "	10 12.6 "	2 39 "

JUPITER.

May 25	20 59.0	−17 42	11 52 P.M.	4 43.2 A.M.	9 34 A.M.
June 5	20 58.9	−17 45	11 09 "	3 59.8 "	8 50 "
15	20 57.5	−17 53	10 29 "	3 19.1 "	8 09 "

SATURN.

May 25	10 01.7	+13 49	10 48 A.M.	5 47.7 P.M.	12 47 A.M.
June 5	10 04.0	+13 35	10 08 "	5 06.8 "	12 05 "
15	10 06.7	+13 20	9 33 "	4 30.1 "	11 28 "

URANUS.

May 25	13 26.4	− 8 26	3 42 P.M.	9 11.8 P.M.	2 42 A.M.
June 5	13 25.4	− 8 20	2 57 "	8 27.5 "	1 58 "
15	13 24.8	− 8 17	2 17 "	7 47.6 "	1 18 "

NEPTUNE.

May 25	4 10.1	+19 27	4 32 A.M.	11 57.2 A.M.	7 22 P.M.
June 5	4 12.0	+19 32	3 50 "	11 15.8 "	6 41 "
15	4 13.5	+19 36	3 12 "	10 38.0 "	6 04 "

THE SUN.

May 25	4 09.8	+21 02	4 23 A.M.	11 56.7 A.M.	7 30 P.M.
June 5	4 54.7	+22 36	4 17 "	11 58.3 "	7 40 "
15	5 36.1	+23 20	4 15 "	12 00.2 P.M.	7 45 "

CERES (1)

May 11	15 50.5	−12 43		12 30 A.M.	
June 4	15 28.8	−13 02		10 34 P.M.	
28	15 15.6	−14 20		8 47 "	

PALLAS (2)

May 23	15 04.5	+26 11		10 57 P.M.	
June 16	14 51.8	+25 21		9 10 "	

JUNO (3)

May 23	16 28.3	— 3 40		12 21 A.M.	
June 16	16 08.9	— 2 56		10 27 P.M.	

THE MOON.

May 20	5 26.8	+23 06	5 41 A.M.	1 33.3 P.M.	9 30 P.M.
25	9 52.0	+17 47	10 03 "	5 38.2 "	1 04 A.M.
30	13 52.9	− 6 58	3 27 P.M.	9 18.7 "	3 00 "
June 5	20 03.0	−23 27	10 36 "	3 04.9 A.M.	7 37 "
10	23 59.5	− 5 49	1 01 A.M.	6 44.1 "	12 35 P.M.
15	4 13.4	+19 27	3 08 "	10 37.7 "	6 16 "

[The above tables give local times for the Central Meridian and latitude +44° 28′.]

Phases of the Moon.

			Central Time. d h m
New Moon	1890	May	18 2 18 P. M.
First Quarter	"	"	26 4 34 P. M.
Full Moon	"	June	3 12 34 A. M.
Last Quarter	"	"	9 3 50 P. M.
Apogee	"	May	24 6 12 A. M.
Perigee	"	June	5 4 06 A. M.

Ephemerides of Saturn's Satellites.

[Computed by A. Marth, Monthly Notices R. A. S., vol. L, No. 1, p. 57. Reduced to Central Time.]

May 15	1.2 a. m.	Di. s.
	2.2 a. m.	Di. Ecl.?
	4.4 a. m.	Te. n.
16	1.0 a. m.	Rh. n.
	3.0 a. m.	Te. s.
	10.0 a. m.	Di. n
17	1.7 a. m.	Te. n.
	4.1 a. m.	Rh. w
	6.9 p. m.	Di. s.
	7.9 p. m.	Di. Ecl.?
18	12.4 a. m.	Te. s.
	7.2 a. m.	Rh. s.
	8.5 p. m.	Rh. c Jap. 2"
	11.0 p. m.	Te. n
19	1.5 a. m.	Tit. s. 37"
	3.7 a. m.	Di. n
	10.3 a. m.	Rh. e.
	2.6 p. m.	En. n.
	4.0 p. m.	Jap c. fol. end of ring 4" s.
	8.3 p. m.	Jap. Transit across ring. Ingress 3" s.
	9.7 p. m.	Te. s.
20	5.5 a. m.	Jap. Egress from ball 6".
	12.6 p. m.	Di. s.
	1.4 p. m.	Rh. n.
	1.6 p. m.	Di. Ecl.?
	2.4 p. m.	Jap. Transit across ring. Egress 2" n
	3.0 p. m.	Jap. c prec., end of ring 2" n.
	7.9 p. m.	Rh. c Jap. 11"
	8.3 p. m.	Te. n.

May 21	4.0 p. m.	En. s.
	4.6 p. m.	Rh. w.
	7.0 p. m.	Te. s.
	9.5 p. m.	Di. n
22	5.7 p. m.	Te. n
	7.7 p. m.	Rh. s
23	6.3 a. m.	Di. s.
	7.3 a. m.	Di. Ecl.?
	4.3 p. m.	Te. s.
	5.3 p. m.	En. n
	10.8 p. m.	Rh. e
24	3.0 p. m.	Te. n
	8.2 p. m.	Di. n
25	1.9 a. m.	Rh. n
	1.6 p. m.	Te. s
	12.0 mdn.	Di. s.
26	1.0 a. m.	Di. Ecl.?
	5.0 a. m.	Rh. w
	12.3 p. m.	Te. n
	7.4 p. m.	Tit. n. 33"
27	8.2 a. m.	Rh. s
	8.9 a. m.	Di. n.
	11.0 a. m.	Te. s
28	9.6 a. m.	Te. n
	11.3 a. m.	Rh. e.
	5.8 p. m.	Di. s.
	6.8 p. m.	Di. Ecl.?
29	8.3 a. m.	Te. s.
	2.4 p. m.	Rh. n
30	2.6 a. m.	Di. n
	7.0 a. m.	Te. n.
	5.5 p. m.	Rh. w
31	5.6 a. m.	Te. s.
	11.5 a. m.	Di. s.
	12.5 p. m.	Di. Ecl.?
	8.7 p. m.	Rh. s.

June 1	4.3 a. m.	Te. n
	8.3 p. m.	Di. n.
	11.8 p. m.	Rh. e.
2	2.9 a. m.	Te. s.
3	1.0 a. m.	Te. n.
	2.9 a. m.	Rh. n.
	5.2 a. m.	Di. s.
	6.2 a. m.	Di. Ecl.?
4	12.3 a. m.	Te. s.
	1.0 a. m.	Tit. s. 33"
	6.0 a. m.	Rh. w.
	2.0 p. m.	Di. n.
	10.9 p. m.	Te. n
June 5	9.2 a. m.	Rh. s.
	9.6 p. m.	Te. s.
	10.9 p. m.	Di. s.
	11.9 p. m.	Di. Ecl.?
6	12.3 p. m.	Rh. E.
	8.2 p. m.	Te. n
7	7.8 a. m.	Di. n.
	3.4 p. m.	Rh. n.
	6.9 p. m.	Te. s.
8	4.6 p. m.	Di. s.
	5.6 p. m.	Di. Ecl.?
	6.6 p. m.	Te. n.
	6.5 p. m.	Rh. w
9	4.2 p. m.	Te. s.
	9.7 p. m.	Rh. s.
10	1.5 a. m.	Di. n
	2.9 p. m.	Te. n.
11	12.8 a. m.	Rh. e.
	10.3 a. m.	Di. s.
	11.3 a. m.	Di. Ecl.?
	1.6 p. m.	Te. s.
	7.0 p. m.	Tit. n. 31"

En. = Enceladus, Di. = Dione; Jap = Japetus; Mi. = Mimas; Rh. = Rhea, Te = Tethys; Tit. = Titan; c = conjunction, e. = eastern elongation; w. = western elongation; n. = north of center of planet, s. = south of center of planet. The conjunctions of the three innermost planets with the ends of the ring take place in the case of Mimas about 3.0h, Enceladus, 3.2h, Tethys, 3.5h before and after the predicted conjunctions with the center, which are not observable.

Minima of Variable Stars of the Algol Type.

	R. A. h m s	Decl. ° ′	Approx. Central Times of Minima.
U Cephei	0 52 32	+ 81 17	May 17, 6 A. M.; 22, 6 A. M.; 27, 6 A. M.; June 1, 5 A. M.; 6, 5 A. M.; 11, 5 A. M.
δ Libræ	14 55 06	− 8 05	May 20, 2 A. M.; 28, 2 A. M.; June 4, 2 A. M.; 11, 1 A. M.
U Coronæ	15 13 43	+ 32 03	May 30, 3 A. M.; June 6, 1 A. M.; 12, 10 P. M.
U Ophiuchi	17 10 56	+ 1 20	May 19, 2 A. M.; 19, 10 P. M.; 24, 3 A. M.; 24, 11 P. M.; 30, 1 A. M.; 30, 9 P. M., June 3, 12 MDN.; 4, 9 P. M.; 9, 1 A. M.; 9, 9 P. M.; 14, 2 A. M.; 14, 10 P. M.

Phenomena of Jupiter's Satellites.

Central Time. d.	h. m.					Central Time. d.	h. m.				
May 16...	Midnight.		I.	Tr.	Eg.	June 1...	12 50	A.M.	I.	Oc.	Re.
22...	2 16	A.M.	II.	Ec.	Dis.		11 16	P.M.	II.	Oc.	Re.
	2 45	"	III.	Ec.	Re.	2...	1 36	A.M.	III.	Tr.	Eg.
23...	1 00	"	I.	Ec.	Dis.	7...	1 59	"	I.	Sh.	In.
24...	12 32	"	I.	Sh.	Eg.		2 01	"	II.	Sh.	In.
	1 48	"	I.	Tr.	Eg.		3 05	"	I.	Tr.	Eg.
	2 09	"	II.	Tr.	Eg.		11 15	P.M.	I.	Ec.	Dis.
29...	3 18	"	III.	Ec.	Dis.	8...	12 34	A.M.	IV.	Sh.	In.
30...	2 53	"	I.	Ec.	Dis.		2 39	"	I.	Oc.	Re.
31...	1 17	"	I.	Tr.	In.		10 47	P.M.	I.	Sh.	Eg.
	1 44	"	II.	Tr.	In.		11 52	"	I.	Tr.	Eg.
	1 49	"	IV.	Oc.	Dis.	9...	12 48	A.M.	III.	Sh.	Eg.
	2 17	"	II.	Sh.	Eg.		1 32	"	III.	Sh.	In.
	2 25	"	I.	Sh.	Eg.		1 40	"	II.	Oc.	Re.
	3 37	"	I.	Tr.	Eg.	15...	1 09	"	I.	Ec.	Dis.

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	Angle f'm N. P't. °	Duration. h m
May 20...	B.A.C. 1801...	6	8 00	32	8 30	329	0 30
June 3...	63 Ophiuchi...	6½	13 34	147	14 25	226	0 51
6...	χ Capricorni...	5½	13 53	347	Star 0.3′ N. of Moon's limb.		

COMET NOTES.

Comet 1882 II (Great Comet). A remarkable paper by M. F. Tisserand is contained in *Bulletin Astronomique*, Feb. 1890, on "The Nuclei of the Great Comet of 1882." It will be remembered that the nucleus of this comet, after its very close approach to the sun, separated into two, and afterward into as many as five separate nuclei lying in a straight line. The writer discusses the orbits of these nuclei, considering them as separate comets, neglecting their mutual attractions, which, he says, must be very small. By a differential method, taking as a basis the orbit of the brightest nucleus (2) calculated by Dr. H. Kreutz, he finds that the nuclei designated (2) (3) and (4) are moving in orbits which differ perceptibly only in the eccentricity, and the elements which depend upon this, the semimajor axis and period. Adopting the period of 772 years for nucleus (2), that for nucleus (3) becomes 885 years and that for (4) 972 years. The measures of the nuclei (1) and (5) were insufficient for the determination of their paths. The period of (1), which was nearest the sun, would naturally be less than that of (2).

The important conclusion to be drawn from these results is that we have here an explanation of the groups of comets which have been observed having almost exactly the same paths, but with periods so long as to exclude the possibility of their identity. The comets of 1843, 1880 and 1882 have very similar orbits, the greatest difference being in their eccentricities, which causes the great difference in their periods, 553, 37 and 772 years. It seems quite possible that at some time in the past these were parts of

one great comet which at its perihelion was separated into parts having different periods of revolution. Mr. Tisserand suggests the conjecture that the comet of 1880 was a fragment of that of 1843.

We may suggest also that both the comet of 1843 and that of 1882 may have been fragments of that of 370 B. C. According to Chambers the comet of 370 B. C. is said to have separated into two parts. The interval 2213 years divided by 4 gives 553 years for the period of the comet of 1843 and 2252 divided by 3 gives 751 years for that of 1882. These periods do not differ unreasonably from the results of the best computations.

Comet D'Arrest. The *Astronomische Nachrichten*, No. 2959, contains an ephemeris of D'Arrest's comet for its return during this year, computed by G. Leveau, of Paris. M. Leveau computed the elements of this comet from the observations made in 1870 and 1877, taking into account the perturbations by the planets, Jupiter, Saturn, and Mars, and calculated an ephemeris for the apparition of 1883, but the comet was too faint to be seen. Owing to other work M. Leveau has not been able to compute accurately the perturbations during the interval from 1883 to 1890, but has determined approximately those by Jupiter. The comet during this interval has been remote from Jupiter, so that the error arising from neglected perturbations cannot be large. The ephemeris gives ground for expecting that the comet may be found at this apparition. The reciprocal of the squares of the distances from sun and earth, $\frac{1}{r^2\Delta^2}$, reaches a maximum of 1.03 August 28, 1890, while during the observations in 1851 it varied from 1.50 to 0.60, in 1857 from 0.23 to 0.16, in 1870 from 0.89 to 0.15, and in 1877 from 0.20 to 0.15. As soon as the comet has been found a more exact ephemeris will be furnished. We give a part of the ephemeris for May and June:

Paris Mean Noon.		α app.		δ app.		$\frac{1}{r^2\Delta^2}$
		h.	m.	°	′	
May	4	16	46.8	+ 7	12	
	8		45.9	8	02	0.23
	12		44.5	8	50	
	16		42.6	9	36	0.28
	20		40.2	10	19	
	24		37.4	10	57	0.34
	28		34.4	11	30	
June	1		31.1	11	57	0.41
	5		27.7	12	17	
	9		24.2	12	29	0.48
	13	16	20.7	+ 12	33	

Comet 1889 I. Dr. R. Spitaler on March 28, 1890, rediscovered and observed this comet with the 27-inch refractor at the Vienna Observatory. Its distance from the sun was then almost five times that of the earth, and its distance from the earth almost exactly the same. No other comet has ever been observed at so great a distance from the sun. Its brightness is about one-twelfth of that which it had at the time of its discovery Sept. 2, 1888, and one hundred and twenty-ninth of its maximum brightness. The following continuation of Dr. Berberich's ephemeris is taken from *Astronomische Nachrichten, No. 2962.*

Berlin Midnight		α app.	δ app.	log r	log Δ	Brightness.
		h m s	° ′			
May	11	18 22 57	−7 28.4	0.7304	0.6660	1.00
	13	21 00	7 24.8			
	15	19 01	7 21.3			
	17	17 00	7 18.0			
	19	14 56	7 14.9	0.7359	0.6638	0.98
	21	12 50	7 12.0			
	23	10 42	7 09.2			
	25	08 33	7 06.6			
	27	06 22	7 04.3	0.7413	0.6636	0.96
	29	04 10	7 02.1			
	31	18 01 56	7 00.1			
June	2	17 59 42	6 58.3			
	4	57 27	6 56.7	0.6466	0.6654	0.94
	6	55 12	6 55.3			
	8	52 56	6 54.1			
	10	50 40	6 53.1			
	12	48 24	6 52.2	0.7518	0.6693	0.91
	14	17 46 09	−6 51.6			

The brightness on March 28 is taken as unity.

Comet 1889 IV (Davidson.) In *Astronomische Nachrichten,* No. 2961 Herr A. Berberich gives the following elements of this comet, computed from six normal places:

$$T = 1889 \text{ July } 19.31081 \text{ Berlin mean time.}$$
$$\left.\begin{aligned} \omega &= 345^\circ\ 51'\ 57.6'' \\ \Omega &= 286\ \ 09\ \ 47.0 \\ i &= 65\ \ 58\ \ 41.1 \end{aligned}\right\}\ 1889.0$$
$$\log q = 0.016890 \qquad q = 1.03966$$
$$\log e = 9.998479 \qquad e = 0.99650$$
$$\log a = 2.47325 \qquad a = 297.34$$
$$\text{Period} = 5127 \text{ years.}$$

Mr. Campbell (*Astr. Jour.*, IX. p. 199) obtained a period of 3,000 years for the same comet.

A Group of Comets. In the same paper Herr Berberich calls attention to a group of seven comets of very long period which have elements quite similar to those of Comet 1889 IV, and which have all come from the same region about the south pole of the heavens.

Comet	T	ω	Ω	*i*	*q*	*e*	Period
1889 IV	July 19.3	345°52′	286°10′	65°59′	1.0397	0.99650	5100 yrs.
1881 III	June 16.5	354 15	271 05	63 26	0.7346	0.99643	3000 "
1888 I	Mar. 17.0	359 55	245 24	42 15	0.6987	0.99607	2300 "
1807	Sept. 18.8	4 08	267 56	63 10	0.6461	0.99549	1700 "
1880 V	Nov. 9.4	11 37	249 30	60 42	0.6527	1.0	
1885 V	Nov. 25.5	35 34	262 15	42 27	1.0790	1.0	
1684	June 8.4	330 35	271 08	65 49	0.9601	1.0	

Of these seven five have appeared within the last ten years. Three of them were discovered in the southern hemisphere with the naked eye, and two were discovered after perihelion in the northern hemisphere. The latter were observed through so short periods of time that the eccentricities of their orbits are uncertain. The importance is suggested of regular search for comets in the south polar regions of the sky.

Discovery of Comet Brooks (a 1890). On the morning of March 19, at 16 hours I discovered a nebulous object, which I at once felt confident was a comet, in R. A. $21^h\ 9^m + 5°\ 35'$. Dawn advanced, however, before I felt positive of the direction of motion, and three leading Observatories, viz., Harvard, Lick, and Warner, were telegraphically notified of my suspected object. The three succeeding mornings were cloudy, but this morning was beautifully clear and I at once found the comet less than one and one-half degrees north of its discovery place. Its position this morning (March 23, 16 hours) was $21^h\ 10^m\ 30^s$ decl. north 7° 15', giving a daily motion of east 22 seconds, and north 25'. The comet is rather bright telescopic, with a stellar nucleus eccentric to the coma. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y., March 24, 1890.

Comet a 1890 (Brooks). Mr. Brooks' letter containing description of the comet discovered by him on the morning of March 20 came too late for the last number of THE MESSENGER. Two sets of approximate elements have been received, one by Rev. G. M. Searle, of St. Thomas College, Washington, D. C. (*Science Observer*, Special Circular, No. 90), the other by Dr. Friederich Bidschof (*Circular der kaiserlichen Akademie der Wissenschaften in Wien*, No. lxxi).

Computer	Searle		Bidschof	
$T =$	1890 June 3.43 Gr. M. T.		1890 June 3.6399 Ber. M. T.	
$\omega =$	74° 01'	1890.0	71° 07' 36"	1890.0
$\Omega =$	320 46		320 44 54	
$i =$	122 00		121 17 13	
$q =$	1.7830		1.8702	
Dates of obs.	Mar. 22, 24, 25.		March 22, 25, 29.	

We have no ephemeris at hand extending beyond May 4. The comet is growing brighter and coming into better position for observation. It may be found in the northeast soon after midnight.

Berlin Midnight.		α app.	δ app.	log r	log Δ	Brightness.
		h m s	° ′			
April	30	21 00 34	+29 23.3	0.2830	0.2743	2.39
May	1	20 59 31	30 12.4			
	2	58 23	31 02.3			
	3	57 10	31 52.9			
	4	20 55 51	32 44.3	0.2806	0.2578	2.62

The brightness on March 21 is taken as unity.

Solar Prominences.—March. Number of observations, 12; number of prominences, 45; mean number of prominences, 3.75; greatest number in one day, 7 (on 4th inst.); highest prominence, 54" (18th inst.).

DISTRIBUTION OF PROMINENCES.

	E. Limb.	W. Limb.		E. Limb.	W. Limb.
0 to 10	1	0	0 to — 10	2	3
10 to 20	0	0	— 10 to — 20	0	2
20 to 30	2	0	— 20 to — 30	0	3
30 to 40	0	0	— 30 to — 40	0	0
40 to 50	1	0	— 40 to — 50	1	1
50 to 60	2	0	— 50 to — 60	0	0
60 to 70	2	0	— 60 to — 70	5	1
70 to 80	2	1	— 70 to — 80	0	3
80 to 90	7	4	— 80 to — 90	2	0
				27	18.

Camden Observatory.

Carleton College Sunspot Observations. Continued from page 136.

Date.	Central Time.	Groups....	Spots.......	Faculae....	Observer..	Remarks.
1890						
Feb. 21.	10.20 A. M.	0	0	0	H. C. W.	
" 27.	2.15 P. M.	1	1	2 gr.	"	Small spot with bright fac. near W. limb.
" 28.	11.45 A. M.	1	1	2 gr.	"	
Mar. 1.	12.30 P. M.	0	0	1 gr.	C. R. W.	
" 4.	3.00 P. M.	1	4	1 gr.	"	
" 5.	12.40 P. M.	1	3	1 gr.	"	Two very large spots.
" 6.	12.30 P. M.	1	6	1 gr.	"	
" 13.	10.30 A. M.	1	3	2 gr.	H. C. W.	Large groups of faculae.
" 14.	12.35 P. M.	0	0	2 gr.	C. R. W.	Faculae NW. and NE.
" 15.	3.10 P. M.	0	0	2 gr.	"	Faculae not very distinct.
" 22.	5.00 P. M.	1	2	1 gr.	"	Spots small. Large group of faculae W.
" 30.	5.00 P. M.	0	0	0	"	
" 31.	10.00 A. M.	0	0	0	"	
April 4.	12.30 P. M.	0	0	0	"	
" 9.	12.30 "	0	0	2 gr.	"	
" 10.	12.30 "	1	3	2 gr.	"	Spots small E. of center. Fac. E.
" 11.	12.30 "	2	4	2 gr.	"	
" 16.	12.30 "	0	0	1 gr.	"	Faculae very near W. limb.
" 17.	12.25 "	0	0	0	"	
" 18.	12.20 "	0	0	0	"	

Smith Observatory Observations. The following solar observations were made in March and April, 1890, with helioscope, powers 98 and 221:

1890.	90 M. M. T.	Groups..	Spots....	Faculae.	Seeing.	Remarks.
1 Mar.	11.30	0	0	0	Poor.	Suspected fac. near E. limb.
2 "	2.50	0	0	0	Very poor.	Hazy clouds.
3 "	2.00	1	3	1 gr.	Fair.	Brilliant fac. surrounding whole group.*
4 "	2.00	1	3	0	Poor.	Fac. still surrounding; nucleus smaller.
5 "	2.00	1	3	0	Very poor.	Fac. same; P. spot now larger
6 "	3.40	1	4	0	Fair.	P. spot dividing, fac. surrounding
7 "	11.00	1	4	0	"	P. spot broken in two; fac. less prominent.
8 "	3.10	1	4	0	"	Surrounding fac. diminished.
12 "	2.30	1	3	1 gr.	Poor.	Fac. near E. limb.
13 "	11.00	1	3	2 gr.	Good.	New fac. about spots; brief fac on S. E. limb.
14 "	2.20	1	1	2 gr.	Fair.	Spot very faint; fac. extended far S.
15 "	2.25	0	0	1 gr.	Very poor.	Gran. difficult; fac. very dim.
20 "	10.00	0	0	0	Fair.	
21 "	11.15	0	0	1 gr.	"	Fac. on E. limb.
22 "	3.00	1	2	1 gr.	Good.	Spots very minute; Fac. nea circle 20″ diam., very bright
23 "	1.00	0	0	0	Poor.	Gran. dif.
24 "	2.25	0	0	0	Bad.	Results negative; clouds.
26 "	11.40	0	0	0	Poor.	Unsatisfactory seeing.
29 "	2.20	0	0	0	Good.	Gran. visible to limb.
30 "	4.20	0	0	0	Poor.	Sun too near horizon.
31 "	11.45	0	0	0	"	Haze; nothing more at 2.15 P.
1 April.	12.00	0	0	0	Fair.	No change at 2.30 P. M.
2 "	12.00	0	0	0	"	Gran. fair.
3 "	4.40	0	0	0	"	Two or three bright regions, n quite fac.
4 "	2.45	0	0	1 gr.	Good.	Gran. good; fac. on E. limb.
5 "	4.43	0	0	1 gr.?	Fair.	Suspected fac. on E. limb.

* Nucleus of f. spot extended almost to limb. Mr. Frost, in the April number THE SIDEREAL MESSENGER, notes prominences on 3rd, and spot on 4th. At abo date eruptive prominences were observed directly over each of the three spots, t highest prominence over the largest spot.

1890.	90 M. M.T.	Groups....	Spots....	Faculae..	Seeing.	Remarks.
6 April	12.00	0	0	0	Fair.	Slight haze.
7 "	12.30	0	0	0	Poor.	Gran. fair.
8 "	12.40	0	0	0	Fair.	At 2 P.M. seeing good, gran. good.
10 "	12.00	0	0	0	Poor.	Gran. dif.
11 "	11.30	2	4	0	Good.	One spot N., ⅔ across; 3 spots S., ⅓ across; gran. good.†

Smith Observatory, Beloit College, CHAS. A. BACON.
April 11th, 1890.

NEWS AND NOTES.

The attention of foreign subscribers is called to the fact that foreign money orders, in payment of dues to THE MESSENGER, should be drawn on St. Paul, for our convenience in collection.

The notice of the discovery of the first comet for 1890, by Professor Brooks, came too late for our last issue, but appears elsewhere in this number, that its record may be complete.

Donohoe Medal of the Astronomical Society of the Pacific. We are pleased to learn that Professor William R. Brooks, of Geneva, N. Y., has been awarded the Donohoe Medal of the Astronomical Society of the Pacific, for the discovery, on March 19, 1890, of the first comet of the year, elsewhere described. It is the first award of this medal by the Society and a deserved honor for Professor Brooks.

Astronomical Society of the Pacific. It is also most gratifying to call the attention of our readers to the phenomenal progress that the Astronomical Society of the Pacific has made during the past year, which is the first year of its history. We do not know anything like it in the history of our science. To our mind it shows the wisdom of bringing the professional astronomer and the amateur in close relation that both may share the advantages of what neither could accomplish alone. The popular influence of such united effort is manifestly excellent.

Observatory Local Patronage. The last month has developed some interesting phases of the question of local patronage for local observatories. One step has been taken which has meaning in it, and that is the preparation of a memorial to be used as shall be decided on later, setting forth the views of astronomers generally concerning the relations of the U. S. Naval Observatory and the Western Union Telegraph Company, and the effect of the same on local Observatories. The signing of this memorial by astronomers in all parts of the United States and by some in

† At 4.20 P. M. 1st and 2nd spots had drifted together and 2nd nucleus had literally cracked into six distinct parts; three new spots (minute) had appeared N. of 3rd spot. Required power of 221 to resolve the "cracked" appearance.

Canada, shows a universality of feeling that was not expected a month ago. Not only this, but there are many who think the time has come when further important steps should be taken to co-ordinate some branches of science in which the Government is interested, and give them a head and management such as they deserve. This memorial is already in the hands of those who will give it the prompt and earnest attention it deserves.

The Western Union Time. Our readers who have had access to the leading dailies of the country already know what has been going on during the last thirty days. Those who have not and care to know may, with advantage, read articles found in the *New York Herald*, March 30 and 31, *Pittsburgh Dispatch*, April 1; *Chicago Tribune*, March 29; *St. Paul Globe*, March 27; also the *Chicago Tribune* of March 28 The remarks of the Superintendent of the United States Naval Observatory in the last named paper concerning us personally are so disgraceful that they are unfit to copy, much less to answer. The language of the slum and the brothel which the superintendent relishes so well shall have no place in THE MESSENGER. Accidents in official place find their true level in time and sometimes speedily. Our friends are exhorted to keep their patience.

Melbourne Observatory. A very neat volume of 131 pages has been received containing the results of astronomical observations made at the Melbourne Observatory, in the years 1881, '82,'83,' 84, under the direction of Robert J. Ellery, Government Astronomer to the Colony of Victoria, Australia.

This volume has an introduction of 20 pages describing the position of the Observatory, the personal establishment, the instrument, mainly the transit-circle, whose object-glass is five inches aperture with focal length of 72 inches, the transit-circle observations, zenith distance observations and manner of printing observations. Then follows the tabular part of the volume, first the work for the year 1881, in which the separate results for mean right ascension of stars, and the separate results for mean north polar distance and then another table showing the mean of individual observations for the same stars numbering 173, in all. For the year 1882 a catalogue of 196 stars was made in the same way, in 1883 the catalogue contained 376 stars, and in 1884, 347.

The convenience of form and neatness and care in detail make this publication a model one, so far as appears from a brief examination.

New Variable Stars in Cygnus. Photographs of the spectra of the fainter stars are now being taken at the Harvard College Observatory with the 8-inch Draper telescope. Their examination by Mrs. Fleming has led to the detection of various interesting objects. The star DM $+48^\circ$ 2942, whose position for 1900 is in R A. $19^h\ 40.8^m$, Dec. $+48^\circ\ 32'$, was found to give a spectrum so closely resembling that of o Ceti and other variable stars of that class that its variability was at once suspected. A photographic chart of this region was therefore taken and a comparison with previous photographs proved conclusively that the star was variable. Argelander estimated its brightness as 7, July 28, 1842, and it is given as 7 1 in

the Durchmusterung. Photographs taken on November 30 and December 1, 1887, show that it was then fainter than the magnitude 11, while on March 30, 1890, it was brighter than the magnitude 7. The photographs at Cambridge cover the greater portion of the sky several times and often permit a suspected discovery to be confirmed without examination of the sky.

EDWARD C. PICKERING.

Harvard College Observatory, Cambridge, April 12, 1890.

A Simple Break-Circuit for Clocks. In the March MESSENGER we published a brief article by Willard P. Gerrish, descriptive of a simple break-circuit for clocks which we had no knowledge of before, and which Mr. Gerrish also believed to be new. From later correspondence, however, it turns out, undoubtedly that Mr. Gerrish reports a re-discovery of a method that haselse where been in use for a long time.

Under date of April 4, Charles H. Chandler, Ripon College, Wis., writes: "The simple break-circuit for clocks, described by Mr. Gerrish in the March MESSENGER, is the same in principle as one employed in Dartmouth College Observatory more than twenty years ago by Professor C. A. Young. I think a mercury contact was employed instead of platinum, but the permanent horse-shoe magnet swinging near the light armature was employed to make the circuit. I have also used a similar device upon an 'Atwood's Machine.' By placing the armature upon one end of a light lever, and counterpoising it with a weight screwed upon the other end of the lever, an admirable delicacy and certainty of adjustment is practicable."

Desiring further information about this interesting device, we asked Professor Young for it. Under date of April 9, he replied as follows:—"Mr. Chandler is quite right. In 1867, I had in use, at the Observatory at Hanover, a break-circuit precisely like that described by Mr. Gerrish, and gave it up because it was not always certain in its action, sometimes failing to break on account of a slight *welding* by the spark at the point of contact."

"As I know now, that could have been easily remedied by making the contact-points of *gold* instead of platinum, but I did not know it then. I had also used a similar break-circuit three or four years before at the Observatory of the Western Reserve College then at Hudson, Ohio."

"But the idea was not original with me—at least Dr. Brunnow of Ann Arbor was earlier. The earliest description of the device, so far as I know, is that given by him about 1859 in No. 19 of the 'Astronomical Notices'—my reference being derived from a paper now before me reprinted from the Journal of the Franklin Institute. This paper (the date of which is not given but it must be between 1862 and 1864) describes and figures a modification of this break by Mr. Robinson (now Professor Robinson of Champaign, Illinois) which was in use in 1864 on two of the clocks used by the Lake Survey Longitude parties. It gave trouble occasionally by "sticking"—*i. e. welding*, as already mentioned was the case with the form I afterward employed. which had a horseshoe magnet below the pendulum instead of the single pole magnet of Robinson."

"The magnetic break is objectionable, theoretically, at least, because variations of temperature alter the attraction between magnet and arma-

ture and so affect the rate of the clock. It is very sensative to slight changes of distance between magnet and armature."

Stellar Parallax. We have inadvertantly omitted to call attention before to a most useful article in *Knowledge* for February by Herbert Sadler on Stellar Parallaxes. In that paper is given a list intended to include all parallaxes published from 1800 to the end of 1889. In this list is given the ordinary designation of the star, its approximate place for 1890, the magnitude roughly to the nearest half in the photometric scale, the name of the observer or publisher of the determinations, the date, the method of observation, the aperture of the instrument employed, a reference to the place of publication, and the actual parallax and probable error as determined by the observer. Though not given the distance of each star in light years in the list could easily be found by dividing 3.262 by its parallax in seconds. This article is so important that we will soon give it place in the MESSENGER. It is hoped that Professors Hall and Elkin will continue the work, and possibly Professor Holden will soon do something in the same direction.

Professor H. A. Howe, Director of the Chamberlin Observatory, of the University at Denver, Colorado, is planning to build a Students' Observatory. This will give much needed facility in connection with the larger Observatory already in process of construction. The student work, by this plan, will not interfere with other in progress by the instruments of the large Observatory. His plan is to have a six-inch equatorial and a two-inch transit for student use. Mr. Brashear, of Allegheny, and Mr. Saegmuller, of Washington, will build the instruments. Mr. Saegmuller reports that the definition of the objective that has been selected is simply "superb."

The Transactions of the Twentieth and Twenty-first Annual Meetings of the Kansas Academy of Science for the years 1887 and 1888 appear in a neatly printed book of 127 pages. A copy is kindly sent us by Librarian B. B. Smith, Topeka, Kansas.

Dust Particles in the Air. An ingenious method has been devised by Mr. John Aitkin for counting the dust particles in the atmosphere. It was found that when the moisture is condensed in a rarified atmosphere each rain-drop has a dust particle for its nucleus, so that by sweeping a measured portion of the air into an exhausted receiver, by means of pure air, and counting the number of deposited drops, it is easy to calculate the number of dust particles in a given volume of the impure air. The counting is managed by having the silver plate in the receiver divided into millimeter squares, so that it is only necessary to count the drops on one square millimeter. Mr. Aitkin showed that the air of a hall contained 400,000 particles to the cubic centimeter, while a specimen of air taken near the roof of the hall gave 3,500,000 to the cubic centimetre. In Edinburgh, on a fine day after snow the number of dust particles in the cubic centimeter was 75,000, but in pure country air the number is often as low as 5,000.—*Science News.*

"*The Chief Discoverers of Comets.*" The revised table given by Professor Swift in THE SIDEREAL MESSENGER, April, 1890, p. 189, differs from mine owing to a difference of method in compilation. In my list, SID. MES., March, p. 122, I counted as discoveries some returns of periodical comets, whereas Professor Swift has omitted these. There is no doubt that a discoverer of an unexpected comet deserves vastly more credit than an observer who, by means of an ephemeris is the first to pick up a periodical comet at its return to aphelion. But it is usual in cometary statistics to give the names of these first observers of returning periodical comets as "discoverers." Thus in Chambers' Catalogue we find their names classed under this heading.

In summarizing results of this character no two persons are likely to agree exactly, because each one will accept or reject details according to his opinion of the circumstances. Thus in my table I included two comets found by Pons in 1808, though not observed sufficiently for their orbital elements to be ascertained. I presume Professor Swift rejected these observations thinking that owing to the want of corroboration Pons was hardly entitled to the merit of discovery.

Professor Swift not very charitably ascribes the differences in our tables to errors existing in mine, but I cannot find any justification for such a statement. Professor Swift is himself in error in attributing 26 comets as the number discovered by Pons, and there are other defects in his table, one of the most serious of which is the entire omission of Messier's name. The latter was the most pertinacious and most successful comet seeker of the last century. W. F. DENNING.

Bristol, April 10, 1890.

American Metrological Society. We have been favored with a copy of the Constitntion of the American Metrological Society and the list of officers for the year 1890. This important organization has for its objects the improvement of existing systems of weights, measures, and money, and to bring them into relations of simpler commensurability with each other. Also to secure universal adoption of common units of measure for quantities in physical observation or investigation, for which ordinary systems of metrology do not provide; such as divisions of barometer, thermometer, and densimeter; amount of work done by machines; amount of mechanical energy, active or passive, of bodies, as dependent on their motion or position; quantities of heat present in bodies of given temperatures, or generated by combustion or otherwise; quantity and intensity of electrodynamic currents; aggregate and efficient power of prime movers; accelerative force of gravity, pressure of steam and atmosphere, and other matters analcgous to them; and to secure uniform usage as to standard *points of reference*, or physical conditions to which observations must be reduced for purposes of comparison; especially temperature and pressure to which are referred specific gravities of bodies, and the zero of longitude on the earth.

Further, to secure the use of the decimal system for denominations of weight, measure, and money derived from unit-bases, not necessarily excluding for practical purposes binary or other convenient divisions, but

maintained along with such other methods, on account of facilities for calculation, reductions, and comparison of values, afforded by a system conforming to our numerical notation

The modes of operation chosen by the Society are very general and specifically stated in the constitution. The plan is a very comprehensive one and deserving of success. The officers of the present year are.

President, B. A. Gould, Cambridge, Mass. Vice-Presidents: T. R Pynchon, Hartford, Conn; Sanford Fleming, Ottawa, Canada, T. C. Mendenhall, Washington, D. C; T. Egleston, New York City; R. B. Fairbairn, Annandale, N. Y, J. H. Van Amringe, New York City. Treasurer and Recording Secretary, John K. Rees, New York City. Corresponding Secretary, O. H. Tittmann, Washington, D. C. Members of the Council H. A. Newton, New Haven, Conn.; Cleveland Abbe, Washington, D. C., R. H Thurston, Ithaca, N. Y.; A. M. Mayer, Hoboken, N. J.; C. F. Brackett, Princeton, N. J.; W F. Allen, New York City; Simon Newcomb, Washington, D. C, S. P. Langley, Washington, D. C; E. O. Leech, Washington, D. C. Geo. Eastburn, Philadelphia, Penn.

The Motion of Hyperion. No. 2 of Vol. 5 of the Annals of Mathematics contains an elaborate article on the motion of Hyperion, by Professor Ormond Stone, Director of the Leander McCormick Observatory of the University of Virginia. In this article, it is first assumed that the planes of the orbits of Titan and Hyperion coincide and the differential equations for the motion of the latter are then written. The co-ordinates which result are only approximate and more accurate ones could be found by a repetition of the same process. It is, however, suggested that the solution can not even be considered as approaching completion until the values of one of the variables are obtained by a comparison of an assumed orbit with observations made near conjunction, and distributed, if possible, over the whole nineteen years, during which another variable makes a cycle of 360°. Professor Stone also suggests that the method used in this article may also be readily extended to cases in which the disturbed and the disturbing bodies do not move in coplanar orbits. The asteroids furnish quite a number of interesting cases of mean motions nearly commensurate with that of Jupiter As examples, may be mentioned (153) Hilda and (190) Ismene, whose mean motions are each approximately three halves that of Jupiter.

Honor for Professor Holden The Astronomical Society of France at its last meeting elected Professor E. S. Holden, Director of Lick Observatory, one of its Honorary Members.

Professor W. A. Crusenberry of Garfield University, Wichita, Kansas, sometime ago sent us a graphic solution of the two simultaneous equations $x^2 + y = 7$ and $x + y^2 = 11$. The geometric figure is a neat one and though not difficult to get, it will soon be given as bearing on some points raised by different persons interested in the algebraic solution to find the values of x and y.

Spectroscopic Observations of Algol. In answer to the queries of an interested reader of the MESSENGER, for information concerning spectroscopic observations of the variable star Algol, we give in full a brief article that appeared in No. 209 of the *Astronomical Journal* as follows:

At the session of the physico-mathematical class of the Berlin Academy of Sciences held November 28, Dr. Auwers presented the following results of the spectrographic observations of the variable star *Algol*, by Professor Vogel and Dr. Scheiner.

Three impressions of the spectrum, taken last winter, had already given evidence that *Algol* recedes from the sun before a minimum, and approaches it after a minimum, Notwithstanding that the lines of the *Algol*-spectrum are not well adapted for accurate measurement, still every impression gave the direction of the motion beyond all doubt, and permitted the determination of its amount with tolerable approximation.

Three new impressions, made within a few weeks, have afforded results completely accordant; and the hypothesis,—long ago proposed but for the most part abandoned since then, on account of the great mechanical and physical difficulties which it entails,—that the variation of *Algol's* light is to be attributed to eclipse by a dark companion revolving around it, now recieves strong support again from these observations

The motion of revolution for the visible star may, from the mean of the six measurements, be assumed as 5.7 geographical miles [42 kilometers*]. Furthermore, the assumption of a circular orbit, described with this velocity, gives when combined with the period of variation, an arrangement of the system somewhat thus:—

Diameter of the principal star	230,000 miles	[1,700,000 km]
" " " dark companion	180,000 "	[1,322,000 "]
Distance of their centers	700,000 "	[5,200,000 "]
Orbital velocity of the companion	12.0	[88 "]

Masses of the two bodies, four-ninths and two-ninths of the sun's mass.

The several results of the observations now at hand are as follows:

	Potsdam M. T.	Distance from Minimum....	Obs. motion toward earth....	Reduction to sun..........	Star toward sun at observation........	Observation ref'd to nearest quadrate.....	Weight........
	d h	h	M.	M.	M.	M.	
1888 Dec.	4 6.6	11.4 after	—5.0	—1.2	—6.2	—7.1	½
1889 Jan.	6 5.7	22.4 before	+6.9	—3.0	+3.9	+4.3	1
"	9 5.5	19.4 before	+7.5	—3.1	+4.4	+4.5	1
Nov.	13 9.3	13.3 after	—5.6	+0.2	—5.4	—5.7	1
"	23 9.0	22.3 before	+6.2	—0.5	+5.7	+6.5	1
"	26 8.5	19.6 before	+6.8	—0.7	+6.1	+6.2	½

Consequently the mean of the observed motions, reduced to quadrature, is

Before minimum, +5.3 miles. After minimum, —6.2 miles.

Wolsingham Observatory. Bright lines were seen in the spectrum of θ_1 as well as in θ_2 Orionis, March 26, and in S Coronæ possibly also April 1, 1890.

T. E. ESPIN.

* A German geographical mile represents the fifteenth part of a degree on the terrestrial equator, or about 7.4 kilometers.

Bulletins of the U. S. Scientific Expedition to West Africa. We have been favored by Professor Todd with bulletins of the U. S. Scientific Expedition to West Africa, numbered 7, 9, 10, 11 and 12, which make our series complete to the last number above named, excepting the first. We have before spoken of other numbers. No. 7, bearing date Nov. 15, 1889, is a paper on a Provisional List of Mammals of Angola and Vicinity, prepared by F. W. True, Curator of Mammals of the National Museum, Washington, D. C. Nos. 9 and 10 are dated December 10, 1889, and contain instructions and suggestions for observing the total eclipse on the 22d of the same month. These were prepared by Professor Todd. No. 11 bears date Dec. 24, 1889, with title, "Terrestrial Physics." This paper was prepared by E. D. Preston. Some of its interesting points are:

That observations of the force of gravity at different points of the earth's surface have brought out the fact that islands are relatively heavy and continental mountains light. The most notoble case is Pinchincha in Peru, at which a density of about one-fifth was deduced for the mountain and the underlying strata. At Halsakala, a mountain in the Hawaiian islands, the density was at least equal to that of the surface rocks. An interesting study for gravity determinations will probably be brought out by this expedition, bearing on some important questions. Bulletin No. 12 is dated Dec. 31, 1889, and signed by Professor Todd, and has for its title, "The Total Solar Eclipse." The substance of this interesting number has already appeared in previous numbers of this journal by kindness of Professor Todd and members of his party.

The Mathematical Magazine. No. 1 of Vol. 2 of this valuable magazine has been received. It is published by Artemas Martin, LL. D., U. S. Coast and Geodetic Survey, Washington, D. C. Quarterly; price one dollar a year in advance.

Knowledge, of April first contains a short letter from Professor Hall, calling attention to what he believes to be the real advantages of the photographic method in astronomical investigation, and also suggesting the possibility of unwarrantable confidence in the exactness of the method. On the latter point he says: "The discussion of the American photographs of the transits (of Venus) of 1874 and 1882, nearly two thousand in number, gives for the probable error of the position of Venus from a single plate about half a second of arc: that is, the photographic method has approximately the same degree of accuracy as an observation with a meridian circle.

Photographics Notes. Monthly Notices for February gives brief records of work done in various departments of celestial photography. The subjects treated are: Professor Pritchard's researches in stellar parallax; Professor H. C. Vogel's investigations of the motions of stars in the line of sight; the work of Professor Pickering, Dr. Scheiner, and Professor Charlier in the line of photometry: and proposed charts of the heavens. Some short quotations from these records follow.

"There can be little doubt that for the delicate work of stellar parallax

as applied to the fainter stars the photographic method must ultimately prevail over all other methods by micrometers or by heliometers." "Six photographs of Algol taken in 1888 and 1889 show a distinct change of motion to be connected with its light period, namely, that before minimum it is receding at the rate of 24.4 English miles per second, while after minimum has been passed the star approaches us with the velocity of 28.6 miles per second. From these velocities it follows that the system of Algol is approaching our system at the rate of 2.3 miles per second, and that the visible star has a velocity in its orbit of 26.3 miles per second. . . Professor Vogel wishes these results to be regarded as provisional only.

Three catalogues of star magnitudes have been prepared by the photographic method at the Harvard Observatory. The first and third of these catalogues is deduced by the method of trails. The second contains magnitudes of stars in the Pleiades group, determined by comparing discs of two stars in the Hyades with those on the Pleiades plates.

Venus in Daylight. Under date of April 8, Mr. A. Cameron, Yarmouth, Nova Scotia, writes that he saw at one o'clock P. M. of that day, the planet Venus distinctly, with the naked eye. He says the sky was perfect. A roof and a couple of chimneys enclosed her and an L on the house shut off the sun.

BOOK NOTICES.

FAITH HEALING. A Defense, or, The Lord thy Healer. By R. L. Marsh, B. D. Fleming H. Revell, Publisher. New York, 12 Bible House, Astor Place. Chicago, 148 and 150 Madison Street. Pp. 147.

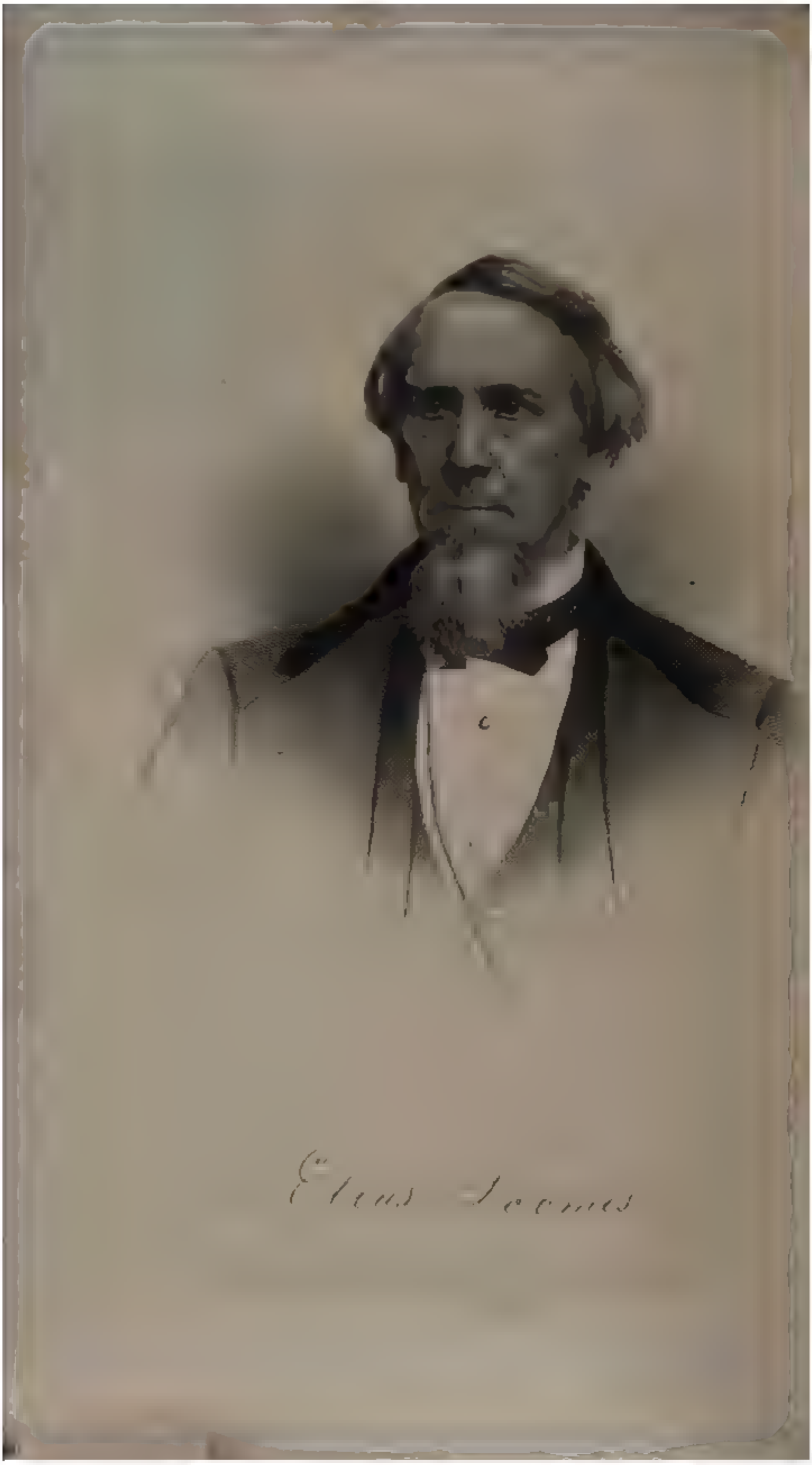
The sentence on the title page suggests the important truth which this new book undertakes to unfold. "It is Christ's words: Whether it is easier to say, Thy sins are forgiven, or to say Arise and walk." There are many thoughtful persons who are asking the question whether the belief that is called "Faith Healing" or Divine Healing is true or not. The friends of this doctrine are heard from in all parts of the world, and some very wonderful things are related by them, the half of which, if true, should lead to careful examination of the facts that the needs of humanity might be met and served in better way if there is new or better balm in Gilead than latter day physicians have known. However this may be, this little book is the outgrowth of one person's experience, through several years of searching for truth with reference to the subject of Faith Healing so-called. The writer says that the Scripture argument is that which at last convinced him, and he put it in writing, as a graduating thesis to be presented with the final examinations to the Faculty of Yale Theological Seminary. By the encouragement of some of the Faculty and other friends the writer's studies have finally assumed the present form. The modest way in which he introduces himself, as he undertakes a most difficult task is very becoming, and we do not see that he sacrifices anything, or loses any strength of position, by saying that he does not yet know all the truth, and does not expect to answer every objection that may be urged against what he shall say, but simply to state doctrine of this mode of healing as he finds it in the Scriptures.

The author's first point is to object to the title of "Faith Healing," because that name is misleading, in that it directs attention to human agency in cure, instead of the divine. Healing is by faith in the same sense that justification is by faith, not the means nor necessarily always the condition of blessing in this way, but it is simply the procuring *act*. It is by the power of God *through* faith in his name. Hence, a better name is Divine Healing.

A brief outline of the doctrine, as given in the first chapter is this: "The Old and New Testaments present the same teaching concerning the cause or origin of disease, and the means of escape from it. The cause of disease is, in general, the devil;" escape from it is through atonement, more fully stated; Deliverence from sickness is one of the conditional blessings of Jehovah's covenant with Israel. The unfaithfulness of the people prevented any full realization of the blessing, yet a recognition of its possibility continued throughout their history. This hope is a large part of the Messianic prophecy. The power and privilege of healing in Christ's name He gave to His disciples as a part of the Gospel and distinctly promised that it should be continued wherever that Gospel was preached. Both earlier and later apostolic teachers confirm and continue that promise.

This is a very brief and very general outline of the subject matter of this book, as it appears from more than twenty different topics in as many different chapters. Christian people commonly believe most of the first part of this outline, but very generally they do not believe that the power which Christ exercised in healing was continued beyond the time of the disciples. On what grounds such a belief should have been given up, or when, or by what authority the power of healing the sick by prayer has been revoked, we do not know. We know that most good people believe that this was one of the special gifts, intended only as a sign to establish the new religion and that it filled its mission in the time of the deciples. But, it is pertinent still to ask what is the authority for this belief? We do not believe such a doctrine is taught in the Bible, but we do believe the author of this new and interesting book is right in his views, because they harmonize in all important essentials with the scriptures on the subject as we have read them for years. In many particulars his detailed statements of different phases of this great study are clearer and better than we have seen or known before. The book has therefore helped us in the use of this wonderful power, and we are grateful for it. The author has done good service in this important field of labor and it is to be hoped, for the cause of truth and great need, his ready and forceful pen will not be long idle.

The Jones' Logarthmic Tables. In a recent number of THE MESSENGER a notice of Professor Jones' new book of Logarithmic Tables was given, setting out somewhat fully the merits of it and calling attention to its convenience of form and arrangement. Professor Jones has earnestly striven to free the tables of all errors and offered liberal reward to any one who would aid him in the work of determining and securing complete accuracy. The edition for 1890 is probably very nearly correct, if not entirely so. The book is 8vo in form, contains 72 pages in flexible cover, price 50 cents; to teachers 25 cents; for introduction 35 cents. Its large open pages, its clear type, and its strong, heavy paper make it an attractive and a durable hand-book for the computer's table.


Elias Loomis

THE SIDEREAL MESSENGER

CONDUCTED BY WM [illegible]

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

VOL. 9, NO. 6. JUNE, 1890.

PROFESSOR ELIAS LOOMIS.*

Elias Loomis was born in the [illegible] Conn., August 7th, 1811. His father [illegible] Loomis, was pastor in that [illegible] 1828. He was a man possessed [illegible] of positive convictions, and of a will [illegible] hazards wherever truth and duty [illegible] might lead. He had studied at Union [illegible] 1799, though apparently he did not [illegible] with his class. He is enrolled with [illegible] lege, and he also received, in 18[illegible] Master of Arts from Yale College. [illegible] to Illinois, and there was instrumental in [illegible] tution which afterwards became Shurtleff [illegible].

Although the boy inherited from his father [illegible] taste, yet his love for the languages also was shown [illegible] very early age. At an age at which many bright boys are still struggling with the reading of English, he is reported to have been reading with ease the New Testament in the original Greek. He prepared for college almost entirely under the instruction of his father. He was, for a single winter only, at the Academy at Monson, Mass. Owing in part to feeble health he was more disposed, in those early years, to keep to his books than to roam with other boys over the Willington hills. In his later life he frequently said that in his early days he never had a thought of asking what subjects he was most fond of, but studied what he was to study.

At the age of fourteen he was examined and was admitted to Yale College, but owing to feeble health he waited [illegible]

* An extract from a memorial address, prepared by Professor H. A. [illegible] delivered in Osborne Hall April [illegible], 1890, at the request of [illegible] Fellows of Yale University.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, No. 6. JUNE, 1890. WHOLE No. 86

PROFESSOR ELIAS LOOMIS.*

Elias Loomis was born in the little hamlet of Willington, Conn., August 7th, 1811. His father, the Rev. Hubbell Loomis, was pastor in that country parish from 1804 to 1828. He was a man possessed of considerable scholarship, of positive convictions, and of a willingness to follow at all hazards wherever truth and duty, as he conceived them, might lead. He had studied at Union College, in the class of 1799, though apparently he did not finish the college course with his class. He is enrolled with that class in Union College, and he also received, in 1812, the honorary degree of Master of Arts from Yale College. At a later date he went to Illinois, and there was instrumental in founding the institution which afterwards became Shurtleff College.

Although the boy inherited from his father a mathematical taste, yet his love for the languages also was shown at a very early age. At an age at which many bright boys are still struggling with the reading of English, he is reported to have been reading with ease the New Testament in the original Greek. He prepared for college almost entirely under the instruction of his father. He was, for a single winter only, at the Academy at Monson, Mass. Owing in part to feeble health he was more disposed, in those early years, to keep to his books than to roam with other boys over the Willington hills. In his later life he frequently said that in his early days he never had a thought of asking what subjects he was most fond of, but studied what he was told to study.

At the age of fourteen he was examined and was admitted to Yale College, but owing to feeble health he waited an-

* An extract from a memorial address prepared by Professor H. A. Newton and delivered in Osborne Hall April 11, 1890, at the request of the President and Fellows of Yale University.

other year before actually entering a class. In college he appears to have been about equally proficient in all of the studies, taking good rank as a scholar, and maintaining it through his college course. President Porter remembers well the retiring demeanor of the young student, and his concise and often monosyllabic expressions, peculiarities which he retained through life. During his Junior and Senior years he roomed with Alfred E. Perkins, whose bequest was the first large endowment of the College Library. He graduated in 1830.

A few weeks before graduation he left New Haven and entered a school, Mount Hope Institute near Baltimore, to teach mathematics, and he remained there for a year and a term. One of his classmates, the late Mr. Cone of Hartford, said that Mr. Loomis had intended to spend his life in teaching, and that it surprised him when he heard that this purpose was abandoned and that Mr. Loomis had gone, in the Autumn of 1831, to the Andover Theological Seminary with the distinct expectation of becoming a preacher. This new purpose was, however, again changed when a year later he was appointed Tutor in Yale College. A vacancy in the Tutorship occurred in the May following (1833) and while not yet twenty-two years of age he returned to New Haven and entered upon the duties of the office. Here he remained for three years and one term. In the spring of 1836 he received the appointment to the chair of Mathematics and Natural Philosophy in Western Reserve College, at Hudson, Ohio. He was allowed to spend the first year in Europe. He was therefore, during the larger part of the year 1836-7, in Paris attending the lectures of Biot, Poisson, Arago, Dulong, Pouillet and others. He did not visit Germany because of want of money. A long series of letters written by him at this time appeared in the Ohio Observer, and the contrast between England and France as he saw them, and the same places as seen by the tourist to day is decidedly interesting.

He purchased in London and Paris apparatus for his professorship, and the outfit for a small Observatory, and in the Autumn of 1837 began his labors at Hudson. Here he remained for seven years, maintaining with unflagging perseverance both his work in teaching and his scientific labors. In judging of this work at Hudson we must remember that

he was not with perfect surroundings. He was without an assistant and without the counsel and encouragement of associates in his own branches of science. The financial troubles which culminated in this country in 1837 were peculiarly severe upon the young and struggling College. Money was almost unknown in business circles in Ohio, trade being almost entirely in barter. In this way principally was paid so much of the promised salary of $600 per annum as was not in arrears. In one of his letters he congratulates himself that all of his bills that were more than two years old had been paid. In another he says that there was not enough money in the College treasury to take him out of the state. When he left Hudson the College offered to pay at once the arrears of his salary by deeding to him some of its unimproved lands.

In 1844 he was offered, and he accepted, the office of Professor of Mathematics and Natural Philosophy in the University of New York. In this new position he undertook the preparation of a series of text books in the Mathematics, and for some years a large part of the time which he could spare from his regular college work was given to the the preparation of these books.

When Professor Henry resigned his professorship at Princeton in order to accept the office of Secretary of the Smithsonian Institution, Professor Loomis was offered the vacant chair. He went to Princeton and remained there during one year, at the end of which he was induced to return again to his old place in the University of New York. Here he continued until 1860, when he was elected to the Professorship in Yale College made vacant by the death of Professor Olmsted. For the last twenty-nine years of his life, he here labored for the College and for science, passing away on the 15th of August, 1889.

Let us look now in succession at the different lines of his activity during these fifty-six years,—four here in the tutorship and in Europe; seven at Hudson, Ohio; sixteen in New York City and Princeton, and twenty-nine in New Haven.

For the first year on returning from Andover to New Haven, he was tutor in Latin, although it seems that he might, had he chosen it, have been tutor of Mathematics. I believe that at the beginning his mind was not yet definite-

ly turned towards the exact sciences. In his childhood he had taken specially to Greek. In college he was equally proficient in all of his studies. He is represented to have led his class at Andover in Hebrew, and now on entering the tutorship he chose to teach the Latin language and literature. During the second year he taught Mathematics, and the third year Natural Philosophy. His later success in scientific work was, I believe, in no small measure due to his earlier broad and thorough study of language.

I have made some inquiry in order to learn what it was that turned his attention and tastes towards science. One of his colleagues in the tutorship, the Rev. Dr. Davenport, says that he recollects very distinctly the first indication to his own mind that Tutor Loomis was turning his thoughts in this direction. The great meteoric shower of 1833 came early in the period of his tutorship, and the views of Professor Twining and Professor Olmstead about the astronomical character and origin of these interesting and mysterious bodies were a common topic of conversation among scientific men in the College, especially wherever Professor Olmsted was present. The tutors were accustomed to meet as a club from time to time in the tutors' rooms in turn, and Dr. Davenport well recollects the occasion when Tutor Loomis brought in a globe and discussed before the club the new theories about these bodies. Up to this time Tutor Loomis had seemed to him to have given his thoughts and study to language rather than to science.

In January, 1834, there were constituted in the Connecticut Academy of Arts and Sciences twelve committees representing the several departments of knowledge, and Tutor Loomis was put on the Committee on Mathematics and Natural Philosophy. These are the only signs of scientific taste or activity which I have detected earlier than the autumn of 1834, after he had been a year and a term in the tutorship. From this time on to the end of his life, he gave his time and energies to several subjects that are enough distinct one from the other to make it convenient to disregard a strictly chronological account of his labors, and consider his work in each subject by itself.

A subject of which he early undertook the investigation was *Terrestrial Magnetism.* We often use the rhetorical

phrase, "True as the needle to the pole," but looked at carefully, the magnetic needle is anything but constant in direction; like the weather vane on the steeple, it is ever in motion, swinging back and forth, in motions minute and slow, it is true, but still always swinging. It has fitfully irregular motions;—it has motions with a daily period;—motions with an annual period; and motions whose oscillations require centuries for completion.

The *daily* motions of the magnetic needle were those which Tutor Loomis first studied. At the beginning of the second year of his tutorship he set up by the north window of his room in North College a heavy wooden block, and on it the variation compass that belongs to the College. Here for over thirteen months he observed the position of the needle at hourly intervals in the daytime, his observations usually being for seventeen successive hours of each day.

The results of these observations, together with a special discussion of the extraordinary cases of disturbance, were published in the American Journal of Science in 1836. No similar observations of the kind made in this country had at that time been published. So far as I am aware none made before 1834 have since been published, except ten days' observations made by Professor Bache in 1832. In fact, I know of only two like series of hourly observations made in Europe earlier than those by Tutor Loomis. He also at this time formed the purpose of collecting all the observations of magnetic declination that had been hitherto made in the United States, and of constructing from them a magnetic chart of the country. He appealed successfully to the Connecticut Academy of Arts and Sciences for its sympathy and aid. The work of collecting facts was so far advanced before leaving New Haven that when he had been a few months Professor at Hudson he forwarded to the American Journal of Science a discussion of the observations thus far obtained, and with them a map of the United States, with the lines of equal deviation of the needle drawn upon it. Two years later he published additional observations and a revised edition of this map.

These were the first published magnetic charts of the United States, and though the materials for their construction were not numerous, and in many cases those obtainable

were not entirely trustworthy, yet sixteen years later, when a map was made by the United States Coast survey from later and more numerous data Professor Bache declared that between his own new map and that of Professor Loomis, when proper allowance had been made for the secular changes, the "*agreement was remarkable.*"

The northern end of a perfectly balanced magnetic needle turns downward, and the angle it makes with the horizon is called the magnetic *dip*. This angle is an important one, and is observed with accuracy only by using an expensive instrument, and taking unusual pains in observing. Hence only a few observations of this element were found by Professor Loomis. From these, however, he ventured to put on his first magnet map a few lines that exhibited the amount of the *dip*.

While he was in Europe he purchased a first class dipping needle, for Western Reserve College, and at Hudson and the neighborhood in term time, and at other places in vacation, he made observations with this needle. Some of these observations were made before his second magnetic chart was published, and upon this map were now given tolerably good positions of the lines of equal magnetic dip. But he continued his observations for several years, determining the dip at over seventy stations, spread over thirteen states, each determination being the mean of from 160 to over 4,000 readings. These observations were published in several successive papers in the transactions of the American Philosophical Society at Philadelphia.

Various papers on terrestrial magnetism, in continuation of his earlier investigations, appeared in 1842, in 1844, in 1847, and in 1859, but movements in Germany, England and Russia had meanwhile been inaugurated which led to the establishment by governments of a score of well equipped magnetic observatories, and this subject passed largely out of private hands.

Closely connected with terrestrial magnetism, and to be considered with it, is the *Aurora Borealis*. In the week that covered the end of August and the beginning of September, 1859, there occurred an exceedingly brilliant display of the Northern lights. Believing that an exhaustive discussion of a single aurora promised to do more for the promotion of

science than an imperfect study of an indefinite number of them, Professor Loomis undertook at once to collect and to collate accounts of this display. A large number of such accounts were secured from North America, from Europe, from Asia, and from places in the Southern Hemisphere; especially all the reports from the Smithsonian observers and correspondents, were placed in his hands by the Secretary, Professor Henry.

These observations and the discussions of them were given to the public during the following two years, in a series of nine papers in the American Journal of Science.

Few, if any, displays on record were as remarkable as was this one for brilliancy or for geographical extent. Certainly about no aurora have there been collected so many facts. The display continued for a week. The luminous region entirely encircled the North Pole of the earth. It extended on this continent on the 2d of September as far south as Cuba, and to an unknown distance to the north. In altitude the bases of the columns of light were about fifty miles above the earth's surface, and the streamers shot up at times to a height of five hundred miles. Thus over a broad belt on both continents this large region above the lower atmosphere was filled with masses of luminous material. A display similar to this, and possibly of equal brilliancy, was at the same time witnessed in the Southern Hemisphere.

The nine papers were mainly devoted to the statements of observers. Professor Loomis, however, went on to collect facts about other auroras, and to make inductinos from the whole of the material thus brought together. He showed that there was good reason for believing that not only was this display represented by a corresponding one in the Southern Hemisphere, but that all remarkable displays in either hemisphere are accompanied by corresponding ones in the other.

He showed also that all the principal phenomena of electricity were developed during the auroral display of 1859; that light was developed in passing from one conductor to another, that heat in poor conductors, that the peculiar electric shock to the animal system, the excitement of magnetism in irons, the deflection of the magnetic needle, the decomposition of chemical solutions, each and all were produced

during the Auroral storm, and evidently by its agency. There were also in America effects upon the telegraph that were entirely consistent with the assumption previously made by Walker for England, that currents of electricity moved from northeast to southwest across the country. From the observations of the motion of auroral beams, he showed that they also moved from north-northeast to south-southwest, there being thus a general correspondence in motion between the electrical currents and the motion of the beams.

When there is a special magnetic disturbance at any place, there is usually a similar one at all other neighboring places. But these disturbances do not occur at the several places at the same instant of time. Professor Loomis showed that in the United States they take place in succession as we go from northeast to southwest, the velocity of the wave of disturbance being over one hundred miles per minute. The waves of magnetic irregularities were thus connected with the electrical current and with the drifting motions of the streamers in the auroral display.

As incident to this discussion, he collected all available observations of auroras, and he deduced from them the annual number of auroras visible at each place of observation. These numbers, when written upon a chart of the Northern Hemisphere, showed that auroras were by no means equally distributed over the earth's surface. It was found that the region in which they occurred most frequently was a belt or zone of moderate breadth and of oval form, enclosing the North Pole of the earth, and also the North Magnetic Pole. It was therefore much farther south in the Western hemisphere than in the Eastern. Along the central line of this belt there are more than eighty auroras annually, but on going either north or south from the central line of that belt the number diminishes.

In 1870 Professor Loomis published a paper of imp tance relating to terrestrial magnetism, in which he sho its connection and that of the aurora with spots on the That the spots on the sun had periods of maxima and ima development had long been known. Lamont had ticed a periodicity in the magnetic diurnal variations, bine and Wolf and Gauthier had noticed that the two

odicities were allied. The connection of the period of solar spots with conjunction and opposition of certain planets had been shown by De La Rue and Stewart. Professor Loomis undertook an exhaustive examination of the facts that tended to confirm or refute the propositions that had been advanced. He confirmed and added to the conclusions of Messrs. De La Rue and Stewart. He also brought together such facts as were relevant to the question, and he showed that the regular diurnal variations of the magnetic needle were entirely independent of the solar spots, but that those disturbances that were excessive in amount were almost exactly proportional to the spotted surface of the sun. He also showed that great disturbances of the earth's magnetism are accompanied by unusual disturbances on the sun's surface on the very day of the storm.

Various forms of periodicity in the aurora have frequently been suggested. Professor Loomis, from all available accounts of the aurora, was able to show that while in the center of the zone of greatest auroral frequency auroras might be visible nearly every night, and hence that periodicity could not easily be shown by means of numbers of anroras recorded in such places, yet that such periodicity was distinctly traceable at places where the average number seen was about twenty or twenty-five a year. The times of maxima and minima of the solar spots were seen to correspond in a remarkable manner with the maxima and minima in the frequency of auroral displays in these middle latitudes. Also from the daily observations made by Messrs. Herrick and Bradley at New Haven during seventeen years, he concluded that auroral displays in the middle latitudes of America are generally accompanied by an unusual disturbance of the sun's surface on the very day of the aurora. The magnetism of the earth, the Aurora Borealis, and the spots on the sun, have thus all three a causal connection, and apparently that connection is closely related to the conjunctions and oppositions of certain planets.

Shortly after the publication of this memoir, Professor Lovering published his extensive catalogue of auroras. A further discussion of the periodicity of the auroras was undertaken by Professor Loomis and published in 1873. In this he made use of all the auroras recorded in Professor

Lovering's catalogue. They confirmed his previous conclusions, only slight modifications being required by the new facts presented, and by their more systematic collation.

In these papers, as in most of his papers upon other subjects, Professor Loomis was ever intent upon answering the questions: What are the laws of nature? What do the phenomena teach us? To establish laws which had been already formulated by others, but which still needed confirmation, was to him equally important with the formulation and proof of laws entirely new.

Let us now turn to another important line of Professor Loomis' work,—*Astronomy*. As I have said, he was early interested in the shooting stars. In October, 1834, he read a paper before the Connecticut Academy of Arts and Sciences upon this subject, probably in substance that which was shortly afterward published in this Journal.* The published paper is principally a restatement of the observations made in Germany in 1823 by Brandes in concert with his pupils for determining the path of the stars through the atmosphere, together with methods of computation. From the results of Brandes' observations, however, he deduces an argument for the cosmic character of the shooting stars. One month after reading this paper to the Connecticut Academy he engaged in similar concerted observations with Professor Twining, who was then residing near West Point, N. Y. These were only moderately successful, but they were the first observations of the kind undertaken in America.

During the senior year of his college course there arrived at New Haven the five-inch telescope, given to the college by Mr. Sheldon Clark, constructed by Dolland. This instrument was much larger than any telescope then in the country. It was temporarily placed in the Athenæum tower, where it was mounted on castors and wheeled to the windows for use. This temporary abode it occupied, however, for over thirty years. In spite of its miserable location it was, in the decade following its installment, a power in the development of the study of Astronomy in the college. The lives and works of Barnard, and Loomis, and Mason, and Herrick, and Lyman, and Chauvenet, and Hubbard, and of other graduates of the college prove this. What rich returns for Mr. Sheldon Clark's twelve-hundred-dollar investment!

* American Journal of Science and Arts.

In 1835 the return of Halley's comet had been predicted, and its appearance was eagerly expected by astronomers and the public: Professor Olmstead and Tutor Loomis first in this country caught sight of the stranger, and throughout its course they noted its physical appearances. With such means as he had at command Mr. Loomis observed the body's place, and computed from his observations the orbit.

The latitude and longitude of an Observatory are constants to be early determined. These were measured by President Day for Yale College in 1811. In the summer of 1835 Tutor Loomis, with such instruments as the College possessed, a sextant and a small portable transit, made numerous observations of Polaris for latitude, and several moon culminations for longitude. From these he computed the latitude and longitude of the Athenæum tower. The longitude from Greenwich, though obtained from a small number of observations, differs less than two seconds of time from our best determinations to-day. While in Europe in 1836–37 Professor Loomis, as I have said, bought for Western Reserve College the instruments for an Observatory. These were a four-inch equatorial, a transit instrument, and an astronomical clock. On his return he erected, in 1837, a small Observatory at Hudson, and in September, 1838, began to use the instruments. He had no assistant, and by day had a full allotment of college work. Two hundred and sixty moon culminations and sixteen occultations observed for longitude, sixty-nine culminations of Polaris for latitude, along with observations on five comets, sufficiently extended for a computation of their orbits; these attested his activity outside of his required duties. Some years later, when the corresponding European observations were made public, he prepared an elaborate discussion of these longitude observations, and published it in *Gould's Astronomical Journal.* A sixth comet was observed by him at Hudson in 1850.

It may not seem a very large output of work in six years' time to have determined the location of the observatory, and to have observed five comets. But we must recollect that the telegraph had not then been invented, that the exact determination of the longitude of a single point in the Western country had a higher value then than it can have now, and that it could be obtained only by slow and tedious

methods. These were, moreover, days of small things in astronomy in this country. At Yale College we had a telescope but not an Observatory. At Williamstown an Observatory had been constructed, but it was used for instruction, not for original work. At Washington Lieutenant Gilliss, and at Dorchester Mr. Bond, were commissioned by the government in 1838 to observe moon culminations in correspondence with the observers in the Wilkes exploring expedition for determining their longitude. These two prospective sets of observations, both of them under government auspices and pay, were the only signs of systematic astronomical activity in the United States outside of Hudson, when in 1838 Professor Loomis began his observing there.

In his Inaugural Address he asks: "Where now is our American Observatory? Where throughout this rich and powerful nation do you find a single spot where astronomical observations are regularly and systematically made? There is no such spot." When he left Hudson in 1844 the situation was not largely changed. Mr Bond had removed his instruments and work to Cambridge. The High School Observatory at Philadelphia had been erected and Messrs. Walker and Kendall were using its instruments Professor Bartlett had built the Observatory at West Point, and had begun to observe there. Lieut Gilliss, after years of excellent work in the little establishment on Capitol Hill, had just finished the present Naval Observatory building at Washington, Professor Mitchel had begun to build the Cincinnati Observatory, and the Georgetown Observatory building had been erected. Professor Loomis's work at Hudson should be measured by what others were doing at the time, rather than by the larger performance of to-day.

In the summer of 1844, the year in which Professor Loomis came to New York, a new method in astronomy had its first beginnings. The telegraph line had just been built between Baltimore and Washington, and Capt Wilkes at Baltimore compared his chronometer by telegraph with one at Washington, and so determined the difference of longitude of the two places.

Professor Bache was now Superintendent of the Coast Survey, and he determined at once to use the new method for the purposes of the survey. To Mr. Sears C. Walker

was committed the direction of the work, but scarcely less important were the services of Professor Loomis, who for three campaigns had charge of the end of the lines in Jersey City and New York. Their first partially successful efforts were made in 1846, but the practical difficulties were overcome and entire success was obtained by them in 1847 and 1848. In these years the differences of longitude of Washington, Philadelphia, New York and Cambridge were thus determined with an accuracy far greater than any previous similar determination whatsoever.

The next summer, that of 1849, Professor Loomis assisted in a like work to connect Hudson, Ohio, with the eastern stations. His observations of moon culminations at Hudson were thus available equally with those made at Philadelphia, Washington, Dorchester and Cambridge for determining the absolute longitudes of Atlantic stations from Greenwich. It was not until 1852 that European astronomers began to use these telegraphic measuring longitudes.

In 1850 Professor Loomis published a volume on the *Recent Progress of Astronomy, especially in the United States.* A first and a second edition were soon exhausted, and in 1856 the volume was entirely rewritten and very much enlarged. Some of the topics in these volumes were the subjects of articles communicated from time to time to the public in this Journal, *Harper's Magazine*, and other periodicals. Another important contribution to astronomy appeared in 1856, that is, his *Introduction to Practical Astronomy*. Eminent astronomers in England and America have expressed in the highest terms their praise of this book. Though it is now thirty-five years since its first appearance, and many treatises on the same subject, some elaborate and some elementary, have since been published, yet for an introduction to practical work I believe that a student will find this volume better than any other for his uses at the beginning of his course.

The increase of our knowledge in Astronomy was, from first to last, an object of special interest to Professor Loomis. Before he left New York the income from his text-books enabled him to make to Yale College the generous offer of coming to New Haven and working in an Observatory at his own charges, provided a suitable Observatory should be con-

structed and equipped for him. Unfortunately, the college was not able, although it was greatly desirous of doing it, to avail itself of his generous offer. Near the same time he joined with public-spirited citizens of New York in an effort to establish an astronomical Observatory in or near that city, and for that purpose an act of incorporation was obtained from the New York State Legislature. After coming to New Haven, he always took the warmest interest in the plans of Mr. Winchester for the establishment of an Observatory in connection with Yale University. His counsel and assistance have been instrumental, more than the public could know, in producing and preserving whatever of value has been developed in that Observatory.

PHOTOGRAPHS OF THE SURFACE OF MARS.

WM. H. PICKERING.

For The Messenger

A box of photographs has recently been received from Mr. Wilson, and contains among other things a number of negatives of the planet Mars. Seven views were taken April 9, between 22^h 56^m and 23^h 41^m, Greenwich mean time. Seven more were taken April 10, between 23^h 20^m and 23^h 32^m. Thus the same face of the planet was presented in both cases. Distinct and identifiable spots and markings are well shown in all the pictures, but in those taken on the latter date a considerable accession is shown to the white spot surrounding the south pole. It has been known for years that the size of these polar spots varied gradually from time to time, apparently diminishing in the summer, and increasing in the winter of their respective hemispheres. But I believe that this is the first time that the precise date, and approximate extent of one of these accessions has been observed. The area affected stretches from the terminator, which at this time was in long. 70°, along parallel — 30° to longitude 110°, thence to longitude 145°, latitude — 45°; thence to the limb which was in latitude — 85° an the 120° meridian, and thence back to the point of starting. It may thus extend also over an unknown area on what was at that time the invisible hemisphere of the planet. The visible area included

is surprisingly large, amounting to about 2,500,000 square miles or somewhat less than the area of the United States. Being near the limb, however, it is not as conspicuous as might at first sight be supposed. On the morning of April 9, the area was faintly marked out as if pervaded by haze, or by small separated bodies, too small and far apart, or too faint to be recognized individually. But on April 10 the whole region was brilliant, fully equaling that surrounding the north pole. In the mean time a much smaller area on the limb which on the 9th was very bright had either vanished or joined the main mass, by moving eastwardly, as we should say, considering Mars as a globe. The date of these events corresponds to the end of the winter season on the southern hemisphere of Mars, or what would be with us about the middle of February. The numerical data given above are founded on the extremely useful tables published by Mr. Marth in the *Monthly Notices*.

As to what these observations mean, might most naturally be explained by terrestrial analogies, but be that as it may, the facts are that these appearances are conspicuous upon each of the fourteen photographs, and so distinctly so, that no one who had once seen them would hesitate an instant in deciding on which day any particular plate was taken.

ON THE REVERSED CURVATURE OF THE SHADOW ON SATURN'S RINGS.

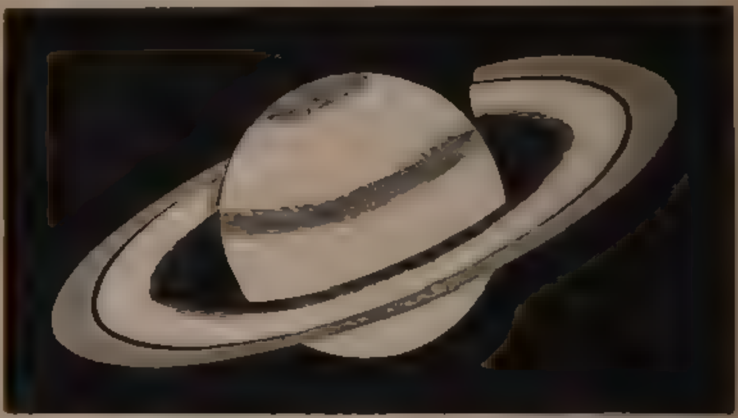
ALDRO JENKS.

For The Messenger.

On the evening of April 25th, 1889, at about 8:30 P. M., I was examining Saturn with a power of about 180 on a 4⅛-inch achromatic by Brashear, when, much to my surprise, I found the shadow of the globe on the rings curved the wrong way, *i. e.* from the globe, as shown in the following drawing, "Fig. I."

Thinking my eyes might be deceiving me I called my wife, and without telling her what I had seen, requested her to describe the shape of the shadow. She described the shadow as having its right hand edge curved away from the planet.

I wrote to Professor Comstock of the Washburn Observatory about it, and was informed by him that while my observation of Saturn was unusual, it was far from being unprecedented; that the same appearance was observed in 1875 with the 26-inch achromatic at Washington, and that Webb, in "Celestial Objects for Common Telescopes," says: "The outline of this shadow has often been found curved the wrong way for its perspective." Professor Comstock also adds, "I do not know that any satisfactory explanation for this anomaly has ever been given."



In seeking the cause of this phenomenon the first explanation which presents itself is, that it is due to some personal idiosyncrasy, or peculiarity of vision of the observer; but when several observers see the same appearance, and this without previous intimation of what they are expected to see, it would seem to exclude that source of error.

As several eye-pieces were used it could not arise from distortion produced by the eye-piece. The objective is an excellent one, and has never shown any distortion of an object; besides, the same appearance has been seen through telescopes of the highest excellence.

It might be thought to be due to atmospheric causes, but it is not to be supposed that on every occasion when this appearance has been observed, the shadow *only* would be distorted by atmospheric causes.

Excluding these sources of error, we are forced to the con-

clusion that the cause of this phenomenon must be sought in some physical peculiarity of the ring system itself.

Long ago, Secchi pointed out that a reversed curvature of the shadow would result from a slight convexity in the ring. This is easily verified. With a lamp, globe and paper rings a little experiment will satisfy anyone that when the portion of the ring on which the shadow falls is made convex, a reversed curvature of the shadow always ensues, placing the eye and lamp in the same position relatively to the globe and ring that the earth and sun occupy to Saturn; and we also find, there is no other shape which can be given to the ring that will produce this effect.

We seem justified, then, in assuming that this appearance is produced by such a shape of the rings. This, however, is not satisfactory. The real question arises, what is the explanation of that explanation? It is evident the surface of the ring cannot be permanently convex, because, in that event, the shadow would always be found curved the wrong way; nor can any portion of the ring be permanently con vex, or we should have this appearance at every revolution of the ring, and as the ring revolves in a little over ten and one half hours, it could be seen at some time on every clear night.

It is now known that Saturn's rings consist of countless independent meteors, moving each in its own orbit about the planet. The so-called crape ring consists of just such meteors, but their number is not great enough to arrest *all* the light and reflect it back to the eye of the observer, as in the two outer ones.

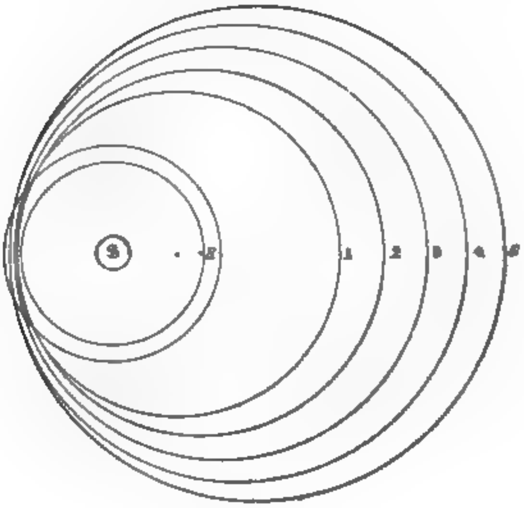
We then have this case, that, when the meteors are crowded together sufficiently they reflect the light so as to present the appearance of a solid, continuous body; but, when they are less numerous, as in the crape ring, they reflect less and still less light as their numbers decrease, up to the point of invisibility.

We know that there are in the solar system myriads of meteors aggregated into shoals, each separate shoal pursuing its course in its own orbit around the sun, being held there by the universal law of gravitation. The attractive power of gravitation, however, does not reside in the sun alone, but, it is conceivable that shoals of meteors might

revolve about a planet, and be held in their orbits by the attraction of its mass.

Now let us suppose there are revolving around Saturn in about the same plane as its rings, but independently of them, several shoals of meteors having one common point of their orbits immediately over the center of the rings, but spreading out to about the same width as the rings and being more numerous at the center than at either edge, and also having various periods of revolution in their orbits.

Such a system as is supposed would be represented in figure two; in which *S* would represent Saturn, *R* the rings, and 1, 2, 3, 4, and 5 the orbits of several shoals of meteorites.



When these several shoals of meteors were at this common point of their orbits at the same time, they would be so crowded together as to reflect the light from immediately over the center of the rings, and from a higher plane, but growing thinner towards each edge more and still more of the light would be reflected from a lower level, passing from the center towards each edge, and thus produce the appearance of a convex surface; and, if that point happened to fall under the shadow at such a time, a reversed curvature of the shadow would be the result.

Moving with different degrees of velocity in their several orbits they would soon be scattered out so as no longer to reflect the light in appreciable quantities, and the rings would again present their normal appearance.

No matter what the orbits or velocity of these shoals of meteors might be, they must all at regularly recurring intervals return to this common point. For illustration, suppose there are five such shoals, revolving in their respective orbits in periods of 1, 2, 3, 4, and 5 days; at the end of sixty days they would all be in conjuction again at this common point. If this point did not also at that time fall under the shadow it would not be percepitble to us (except at those rare intervals when the edge of the ring is turned towards us, when it would be seen as a bead of light), another sixty days must then ensue, and so on, until some conjuction would be found to fall under the shadow. But as the shadow covers only a small portion of the rings it is evident that this condition could be observed only at rare and irregular intervals.

If only a portion of the shoals were in conjunction, say those whose orbits lay more immediately over ring *B*, then the shadow might present a notched appearance as has been observed by Schroeder, La Place, De la Rue and Jacob.

Only two objections to this hypothesis present themselves to my mind, neither of which, it seems to me, is fatal to the theory. The first is that it would require two sets of shoals, one on each side of the ring, as the shadow has been found thus curved on both sides of the rings. When seen at Washington in 1875 the shadow must have been on the north side, and when seen by me it was on the south side of the rings. According to the nebular hypothesis, this ring system must have been formed by the contraction of nebulous matter from a more widely diffused state, and the lateral attraction would be towards the center, instead of towards the extreme side of the mass. This would probably result in leaving outlying portions of meteoric matter on each side of the rings.

The other objection that might be urged is, that the attraction of the rings would swerve these meteoric shoals from their paths, and cause them to be absorbed into, and become a part of the rings. But this objection would be just

as fatal to the theory that the rings are composed of meteorites, as it would to the hypothesis I have proposed. Granting the force of the objection, the process still might be an extremely slow one, like the earth gathering up the meteorites during the November showers. It would simply follow that it is only an existing phase of the ring system we observe, but that "existing phase" might extend over many thousands of years.

Besides the facts above mentioned, this hypothesis derives some support from the fact that the divisions in the rings have, at times, been observed to be partially obliterated; and from the further fact that there is a small percentage of outstanding perturbations of the inner satellites unaccounted for.

Accepting this hypothesis, we could account for these anomalous appearances in a manner justified by experiment, also for their appearance at rare and irregular intervals and only at such intervals, for the notched appearance the shadow sometimes presents, for the beads of light sometimes seen in connection with the rings when the edge is turned towards us, and for their non-appearance at other times under similar circumstances; in short, it seems to me, that this hypothesis is competent to account in a rational manner for all the observed phenomena, while the observed facts certainly call for some explanation.

It also seems reasonable to suppose that shoals of meteors should abound in connection with meteoric rings.

Why then should we not accept this hypothesis until some more probable explanation is proposed to account for the facts?

DODGEVILLE, Wis., Dec. 4th. 1889.

CELESTIAL PHENOMENA EXPLICABLE BY METEORS.*

W. H. S. MONCK.

Although I am of the opinion that we have no conclusive evidence of the existence of meteors outside the limits of the solar system, I think it will be conceded that their existence

* A paper read before the Royal Dublin Society in January, 1886.

is highly probable; and this probability may be raised to something approaching certainty if we are able to explain by their means phenomena of which no other satisfactory explanation has been given. The first phenomenon, however, with which I propose to deal lies within the solar system, where we know as a fact that meteors abound, and the only question is as to the sufficiency of the proposed explanation. I allude to the shortening of the major axis of the orbit of Encke's comet, which is usually ascribed to the presence of a resisting medium. Now it seems to me that without supposing that the ether offers any resistance to motion, or that there is a solar atmosphere of great tenuity extending as far as the orbit of the Encke's comet, this resistance may be accounted for by the flights of meteors which the comet must encounter in the course of its revolution. It is true that some of the meteors probably overtake the comet and thus tend to accelerate its motion, but the comet probably overtakes an equal number, and is thus retarded to the same extent. So much for the cases where the comet and the meteors are both moving towards or from their respective perihelia, but the majority of the collisions occur when they are moving in opposite directions,—the comet approaching the sun and meteors receding from it, or *vice versa*. Moreover, the retardation is in this case proportional to the sum of the velocities of the comet and of the flight of meteors, while if the same flight overtook the comet the acceleration would be proportional to the difference of the velocities, which would usually be very small. The total effect of the collisions between the comet and the meteors must, therefore, be to retard the motion of the comet. It has been computed that 7,500,000 meteors, on an average, enter our atmosphere every day. I should be disposed to make a lower estimate, but a much lower one would be sufficient for my purpose. These meteors produce no perceptible effect on the earth's motion, but the result might be very different if the earth, while occupying the same space as before, was reduced to one-millionth part of its weight. This would assimilate it more nearly to the condition of the comet; and meteors are probably more densely packed in space as we approach the sun. I have not made any mathematical computations on the subject but I think when they

are made it will be found that the observed retardation of Encke's comet may be accounted for by collision with meteors without increasing the number and velocity of these meteors to an incredible extent.

Some time ago, in a paper read before this Society, I noticed the great decline of light among the fainter stars, and suggested as an explanation that the ether absorbs light. I was not aware at the time that a somewhat similar theory had been previously put forward by the great astronomer Struve. But it has since occurred to me that this decline of light in the case of remote stars may be due to the interposition of flights of meteors. To show the credibility of this explanation I desire to call attention to the great extent of surface which a body of moderate dimensions may be made to exhibit by breaking it up into small fragments. To take the simple case of spheres, the solid contents of a sphere is proportional to the cube of the radius, while the surface is proportional to the square of the radius, and therefore if we could parcel out a large sphere completely into small spheres, the total extent of surface would be enormously augmented. Suppose the radius of each small sphere to be $\frac{1}{n}$th of that of the large one the number of these spheres would be n^3 and the surface of each would be $\frac{1}{n^2}$ of that of the large sphere, so that if the small spheres were so arranged that none would be placed behind another the total surface would be n times as great as before. It would, indeed, probably be still greater because the interior portions of the large sphere would be in a state of great compression while those of the smaller spheres would not. It is very probable that the average size of a meteor does not exceed that of a sphere with a diameter of three inches. If the moon was cut up into such spheres its surface would be multiplied by forty-five millions, and if the spheres were not placed behind each other they would cover a portion of the sky nearly equal to that now occupied by the moon, when removed to the distance of Uranus. They would probably occupy a still larger portion of the sky if scattered up and down between the sun and the orbit of Neptune. But if the number of meteors which the earth encounters every day is to be reckoned by millions or even by hundreds of thousands, I think it is not unreasonable to suppose that the entire number of them

comprised within the orbit of Neptune would form a body as large as the moon, in which case the quantity of light intercepted by them could not be regarded as inappreciable. Now supposing that meteors in anything like the same numbers are to be found in the remoter regions of space, the diminution of light owing to their presence must be considerable. They would probably be most thickly packed in the regions where the fixed stars are most numerous and their influence in diminishing the light of the fainter stars would be most observable in these directions. If, moreover, there is the same connection between meteors and nebulæ that is known to exist between meteors and comets, we may expect to find them densely crowded in the neighborhood of true or gaseous nebulæ, producing in such cases a very considerable diminution of light. At all events I think the observed declension in the light of the fainter stars may be accounted for by the interposition of meteors without assigning either an incredible density to these meteors or an incredible distance to the stars whose light they intercept.

I now pass to a class of variable stars together with the stars known as new stars. Some variable stars like Algol probably belong to a different class, but the characteristics of the class to which I refer and which I may call irregular variables are sufficiently startling. They often attain a very considerable degree of brilliancy and then fade away rapidly. The known laws of cooling seem to exclude the supposition that large bodies could change their temperature so rapidly, and, moreover, even when the star is brightest, the spectrum does not seem to indicate that the temperature is abnormally high. Are they then small bodies? Apparently not; for if so, they must be near us; whereas none of them, I believe, has as yet been found to exhibit a sensible parallax. The difficulty, I think, disappears if we suppose a new star to consist of a number of small bodies so near together that our telescopes cannot separate them. Saturn's rings are now generally believed to consist of numbers of small bodies of this description: and supposing that one of our great meteor showers could be seen from α Centauri by a telescope much more powerful than Lord Rosse's, it is almost certain that it would be taken for a single luminous object. A dense cloud of meteors heated to luminosity

might be visible to a great distance, but as each individual meteor would be very small, cooling would follow rapidly when the source of heat was withdrawn. Again if the meteors were exposed a second time to the source of heat, their luminosity would augment as rapidly as it had previously diminished. Some of the new or irregularly variable stars to which I refer have, moreover, appeared to present planetary discs rather than to resemble ordinary fixed stars. This gives us the idea of much enlarged dimensions—of a cloud of meteors with a diameter of several millions of miles, rather than a single body with a diameter much less than that of the sun.

I think we can go further and assign a probable cause for the luminosity of these meteors. We know that those which we experience are not luminous until they enter the atmosphere, but are raised to luminosity by rushing through it. A similar effect would be produced by a body of meteors rushing through any other gaseous mass. But we have undoubtedly in space masses of gas whose dimensions exceed that of our atmosphere perhaps as much as the sun exceeds one of our atmospheric meteors. A cloud of meteors rushing through such a mass of gas would be visble to a great distance. It would probably either be partly vaporised or would heat the gas through which it was rushing to such a degree as to produce more or less of a gaseous spectrum in connection with the continuous spectrum of the heated meteors. But it has been remarked that these irregularly variable stars and new stars almost always appear in connection with a nebula, and when at their greatest intensity there is usually a trace of a gaseous spectrum along with the continuous spectrum of the star. Mr. Proctor has moreover observed that they almost always occur close to, or in, the Milky Way, and therefore just in the places where we might expect to find the largest number of meteors.

I am aware that the great Andromeda nebula in which the last of these new stars has appeared, is not supposed to be gaseous, inasmuch as its spectrum is continuous, though apparently shortened at the red extremity. This fact, however, is not conclusive as to the absence of a large mass of gas in the locality in question. The deficiency at the red extremity is moreover greater in the case of the nebula than of

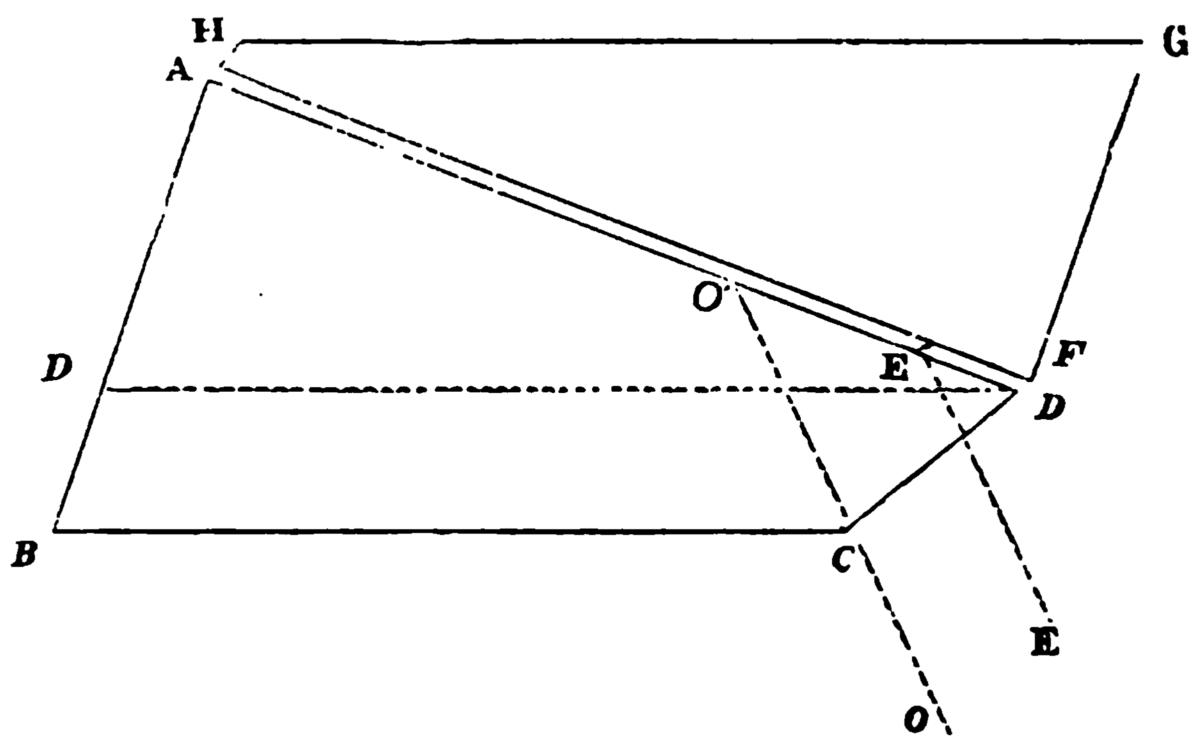
any known star, and in this respect the spectrum resembles that of the nucleus of the comet known as Coggia's, which was probably in a partly gaseous condition. The deficiency at the red end may be due to the intervention of an absorptive gas, or possibly to the intervention of a cloud of meteors if it should prove that red light loses more in bending round a small object than light of higher refrangibility. At all events, flights of meteors rushing through a gaseous medium seem to me to explain more of the facts than any other theory hitherto proposed, and if we have independent reasons for believing in the existence of these flights of meteors this explanation attains a high degree of probability.

In conclusion, I may make a remark as to the theory which would ascribe the solar heat, or at all events its maintenance, to collision with meteors. As far as our experience reaches, the orbits of meteors are not such as would lead them to fall into the sun. They appear to be of a cometary character, and no comet has as yet been known to fall into the sun. Nearer to the sun, indeed, meteors may be moving in orbits of a different character; but where do these meteors come from? If they do not come from inter-stellar space or from the outer portions of the solar system (in either of which cases we might expect to meet with some of them while travelling towards the sun), we can hardly account for their existence otherwise than by ejection from the sun himself: and it seems pretty obvious that the sun could not acquire heat by ejecting particles from his surface and then catching them again in their descent. The ejection and recapture may very possibly occur; but if so, the heat given back by the recapture has evidently been derived from the sun himself and represents heat given out otherwise than by the ordinary process of radiation. The problem how the sun can give out such a quantity of heat by radiation and still retain his temperature therefore remains unsolved, unless there is some special reason why the meteors from outer space which are destined to fall into the sun should avoid the earth when approaching their destination. But I doubt if any such special reason can be assigned. As regards the earth, I may notice that no marked rise of temperature has been observed even after the densest meteor shower. Why should it be otherwise with the sun?

POLARIZED REFLECTIONS IN A NICOL'S PRISM.

E. J. SPITTA.

In a paper read before the R. A. S. on Friday, March 14, attention was called to the peculiar effect of using a polarizing apparatus to evaluate a Pritchard's wedge without the employment of a diaphragm placed between the Nicol and the eye. It was not within the scope of that paper to speak of what I submit may be an explanation of the cause *why* the internal reflections in the prism demand its being turned through a greater or less angle according to the position of the zero, than is found to be necessary when a diaphram is employed, so perhaps the following remarks may be worthy of notice by those who are interested in the subject. To explain the matter clearly, a diagram and brief explanation of one of the Nicols I had specially cut to show the rays immediately before their last reflection must be given.



It will be noticed first that this nicol differs from an ordinary one in being much wider from H to B and G to C than is usual, an imaginary line drawn from F or D parallel to BC to meet the line AB at D′ being the usual limit of the spar. The diagram speaks for itself and shows the prism separated, but ready to be united with Canada balsam. If now the portion ABCD be firmly fixed, say, in a Bunsen's holder, and a slit be placed before AB between the spar and a candle protected by a monochromatic piece of glass, whilst the eye is placed at CD, several images will be seen; but the most prominent are those formed by the extraordinary ray seen in the direction EE′ and that due to the ordinary ray

OO′, both of which are evidently due to reflections from the surface AD. But if these images be looked at attentively, and especially if the prism be itself slightly moved, they will be found to be double, the fainter image in each case being polarized in the opposite plane to that which is the more intense. Hence four images are really to be seen—a strong one extraordinarily polarized, side by side with a feeble one ordinarily polarized, and at some distance a strong ordinary, side by side with a feeble extraordinary. But this is not all. Owing to the angle which the prime extraordinary ray makes with the surface AD, being so close to, if not actually less than, the critical angle for that ray, total reflection takes place until the optical continuity of the spar, so far as it relates to this ray, is completed by the Canada balsam with the piece HFG. If now this second piece HFG be affixed with balsam whilst the eye watches the strong ray EE′ through the surface CD, it will be seen that it does not entirely pass through the balsam as many authorities aver, but, on the contrary is only partially transmitted, for the image still reflected after union is made with the piece HFG is by no means a feeble one. If, now, a tourmaline is so placed over the face CD as to exclude *both* extraordinary rays the images formed by the two ordinary ones will alone be visible, and it will then be found that the plane of the faint ordinary, which was side by side with the strong extraordinary image, *is slightly turned on its axis.* In other words, if a second Nicol be employed and placed between the eye and the tourmaline, the two images will not become evanescent at the same angle of rotation of the Nicol; and if the tourmaline be now moved so as to hide both *ordinary* images and leave the two extraordinary ones, they also will be found *not to disappear at the same moment,* but sensibly one after the other. Lastly, and most important, if the plane of the extraordinary image as seen at the surface GD be compared with that of EE′ and that of OO′, it will be found the planes of the first and last are very nearly if not quite coincident, but that the plane of polarization for *both* rays at EE′ *is sensibly rotated.* How it arises that the plane of one set of reflections is more rotated than that of the other, I must leave to those more versed in optical mathematics; but the fact is patent enough with any reasonable

inspection of the Nicol in question. Inasmuch then as these rays are among those cut off by the diaphragm it is proposed to use, for in an ordinary Nicol they would be again reflected off the surface DD′, it is, I submit, open to consideration whether their presence, if unchecked, would not be sufficiently potent to cause the prism to be under-rotated or over-rotated, according to which side of the zero the observation was made. The result of such an over and under turning would be that the angle enclosed between the two points of equalization would be fasely reduced and the ratio obtained correspondingly too high. But as the computed ratio of light practically depends on $\cot^2 \frac{1}{2}(q'-q)$, an error in the determination of this angle would introduce an alteration in the ratio of the lights of

$$-2 \cot \tfrac{1}{2}(q'-q) \operatorname{cosec}^2 \tfrac{1}{2}(q'-q) \triangle \tfrac{1}{2}(q'-q).$$

This is only another way of saying that, with intensities which vary but little, half a degree (neglecting squares and products) would alter the ratio from 2.13 to 2.05, where one, for example, is but twice as bright as the other; but in the case of the ratio dealt with being higher, such, for example, as 1 to 18, the alteration produced by half a degree would amount to 1.133. Consequently, the amount of error produced in the coefficient of a wedge would vary with its depth and with its density, provided the same distance between the slits was rigidly maintained.—*The Observatory*, No. 162.

EQUATION OF THE ELLIPSE THROUGH FIVE GIVEN POINTS.

CHAS. E. MYERS.

For The Messenger.

If we divide the equation $Ay^2 + Bxy + Cx^2 + Dy + Ex + F = 0$ by F, denoting the new coefficients by subscripts, we have $A_1y^2 + B_1xy + C_1x^2 + D_1y + E_1x + 1 = 0$. Substituting in this the co-ordinates of the five points, we get:

$$A_1y_1^2 + B_1x_1y_1 + C_1x_1^2 + D_1y_1 + E_1x_1 + 1 = 0$$
$$A_1y_2^2 + B_1x_2y_2 + C_1x_2^2 + D_1y_2 + E_1x_2 + 1 = 0$$
$$A_1y_3^2 + B_1x_3y_3 + C_1x_3^2 + D_1y_3 + E_1x_3 + 1 = 0$$
$$A_1y_4^2 + B_1x_4y_4 + C_1x_4^2 + D_1y_4 + E_1x_4 + 1 = 0$$
$$A_1y_5^2 + B_1x_5y_5 + C_1x_5^2 + D_1y_5 + E_1x_5 + 1 = 0$$

The values of A_1 B_1 C_1 D_1 and E_1 determined from these five equations, and substituted in the equation $A_1y^2 + B_1xy + C_1x^2 + D_1y + E_1x + 1 = 0$, gives an equation of a conic section passing through five points, $x_1y_1 : x_2y_2$ etc.

When $B^2 - 4AC < 0$ the section is an Ellipse,

When $B^2 - 4AC > 0$ the section is an Hyperbola,

When $B^2 - 4AC = 0$ the section is a Parabola,

When $B^2 - 4AC = 4(e^2 - 1)$, and $e =$ eccentricity of the curve.

TABLES FOR THE DETERMINATION OF THE MERIDIAN OF ELONGATION OF POLARIS.*

LÆNAS GIFFORD WELD.†

The following tables have been computed for the use of land surveyors and engineers during the current year (1890). In Table I. the times of elongation are given to the nearest ten seconds, and the azimuths to the nearest five seconds of arc.

TABLE I.

Azimuths at Elongations and Local Mean Times of Elongations of Polaris for 1890, Latitude 41°40′ N., and Latitude 6ʰ west of Greenwich.

Civil Date	Azimuth	Eastern Elongation	Western Elongation
	° ′ ″	*h. m. s.*	*h. m. s.*
January 1	1 42 20	12 37 40 P.M.	12 30 40 A.M.
February 1	1 42 20	10 35 20 A.M.	10 24 10 P.M.
March 1	1 42 30	8 44 50 "	8 33 50 "
April 1	1 42 40	6 42 40 "	6 31 40 "
May 1	1 42 55	4 44 50 "	4 33 50 "
June 1	1 43 5	2 43 20 "	2 32 20 "
July 1	1 43 5	12 45 50 "	12 34 50 "
August 1	1 43 0	10 41 30 P.M.	10 33 20 A.M.
September 1	1 42 50	8 39 0 "	8 31 50 "
October 1	1 42 35	6 41 20 "	6 34 10 "
November 1	1 42 20	4 39 20 "	4 32 20 "
December 1	1 42 5	2 41 10 "	2 34 10 "
January 1, 1891..................	1 41 55	12 38 50 "	12 31 50 "

The local mean times of elongation should be increased 9.8ˢ for each hour of longitude *east* of the meridian of the table, and diminished by the same amount for each hour *west*.

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* From *The Transit*, Vol. II., No. 1, a semi-annual publication of the Engineering Society of the State University of Iowa.

† Professor of Mathematics and Astronomy, University of Iowa.

If standard time be employed it should be reduced to local mean time.

By means of the auxiliary tables given below, the above table may be used through a range of ten degrees of latitude.

TABLE II.

For other latitudes within 5° of 41° 40′ N., the following corrections are to be added (algebraically) to the azimuths of Polaris given in Table I.

North	Difference in Latitude	South
′ ″	°	′ ″
1 39	1	−1 35
3 24	2	−3 4
5 13	3	−4 29
7 7	4	−5 49
9 6	5	−7 4

TABLE III.

For other latitudes within 5° of 41°40′ N. the following corrections are to be added (algebraically) to the times of eastern elongation, and subtracted (algebraically) from the times of Western elongation given in Table I.

North	Difference in Latitude	South
s	°	s
10	1	− 9
20	2	−19
31	3	−28
41	4	−37
52	5	−45

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury, having just passed inferior conjunction, will not be in good position for observation until the latter part of June, when it will rise about an hour earlier than the sun. It will be at greatest elongation west from the sun, 22° 20′, June 23; in perihelion July 15; at superior conjunction with the sun July 22; in conjunction with Saturn, south 34′, August 9, at 11 P. M. Mercury will be in good position for daylight observations of the gibbous phase during the first half of July and the same part of August.

During the first days of May this planet was quite conspicuous to the naked eye in the evening and we had several excellent views of it with the telescope both during the day and at night. Only once were we able to make out any sign of a dusky marking upon the disk, and that was very indistinct.

Venus must be recognized by any one who looks toward the west in the evening, her brilliancy far exceeding that of any other object in western sky, except the moon, and being sufficient to cause perceptible shadows of objects upon the earth. She is easily visible to the unaided eye at noon, if the air is clear and the observer knows just where to look. With the 8-inch telescope we have not as yet been able to discover any trace of dark markings upon the surface of the planet. *L'Astronomie* (May, 1890, p. 192), has however, received from Professor Schiaparelli some important researches tending to verify the adopted value of the rotation period of Venus. These researches will be published in *L'Astronomie*. We shall look for them with interest.

Mars is now at his least distance from the earth, for this opposition, –45,000,000 miles. This planet is very conspicuous in the southeast at 10 P. M. in the constellation of Scorpio. Mars will move westward through the constellation until July 4, after which it will move eastward, coming to conjunction with *Antares* August 13. The diameter of Mars, June 1, is 20.8″, July 1, 19.0″, August 1, 15″; the phase June 1, 0.997, July 1, 0.945, August 1, 0. 883. It is unfortunate for observers in the northern hemisphere that when Mars is nearest his declination is lowest, so that he is seen under unfavorable circumstances. It is to be hoped that astronomers in the southern hemisphere, where Mars approaches the zenith, wil pay much attention to the study of his surface, during this opposition and the one in 1892.

Jupiter also will be best seen in the southern hemisphere. He will describe a short retrograde path in Capricorn where there are no bright stars. He may in our latititude be found in the southeast after midnight in June, after 10 P. M. in July, and after 8 P. M. in August. The polar diameter of Jupiter's disk will be 41. 4″ June 1, 44. 8″ July 1, and 46. 2″ August 1. He will be at opposition July 30. Transits of the shadow of satellite IV will be comparatively frequent during this summer and micrometrical measurements of the position of this shadow upon Jupiter's disc, with the exact time of the measurements, will be of value for determining the elements of the satellite's orbit.

Saturn may be seen toward the southwest in the early evening in the constellation Leo, near the bright star Regulus, and will move slowly eastward in that constellation. The sun is gaining rapidly upon him, however, so that in August Saturn will be lost to sight. On July 17, at $10^h\ 36^m$ A. M., Saturn and Venus will be in conjunction, Venus being only 6′ south of Saturn.

Uranus will be at quadrature, 90° east from the sun, July 14. He may be found on the meridian at about 8: 30 P. M., a little northeast of the star Spica in Virgo, between the fifth magnitude stars *h* and *S* Virginis, and is moving very slowly.

Neptune is on the other side of the sun and so will not be visible this summer.

MERCURY.

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 25	4 43.4	+19 11	3 05 A.M.	10 28.5 A.M.	5 52 P.M.
July 5	5 40.8	+22 16	3 08 "	10 46.3 "	6 25 "
15	7 04.0	+23 27	3 45 "	11 30.1 "	7 15 "
25	8 34.9	+20 30	4 52 "	12 21.4 P.M.	7 51 "
Aug. 5	9 59.9	+13 46	6 03 "	1 02.7 "	8 02 "
15	11 01.4	+ 5 56	6 59 "	1 26.3 "	7 53 "

VENUS.

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
June 25	8 36.0	+20 29	6 51 A.M.	2 20.4 P.M.	9 50 P.M.
July 5	9 24.2	+17 05	7 15 "	2 29.1 "	9 43 "
15	10 10.0	+12 57	7 40 "	2 35.4 "	9 31 "
25	10 53.7	+ 8 19	8 03 "	2 39.8 "	9 16 "
Aug. 5	11 39.8	+ 2 51	8 28 "	2 42.4 "	8 57 "
15	12 20.5	– 2 16	8 48 "	2 43.6 "	8 39 "

MARS.

1890.	R. A. h m	Decl. ° '	Rises. h m	Transits. h m	Sets. h m
June 25	15 42.1	−22 41	4 58 P.M.	9 25.2 P.M.	1 52 A.M.
July 5	15 39.9	−22 45	4 21 "	8 43.7 P.M.	1 06 "
15	15 43.5	−23 02	3 43 "	8 08.0 "	12 33 "
25	15 52.5	−23 31	3 19 "	7 37.6 "	11 56 P.M.
Aug. 5	16 07.6	−24 11	2 50 "	7 09.4 "	11 29 "
15	16 25.3	−24 50	2 32 "	6 47.8 "	11 04 "

JUPITER.

June 25	20 54.9	−18 06	9 48 P.M.	2 47.9 A.M.	7 26 A.M.
July 5	20 51.3	−18 23	9 07 "	1 54.2 "	6 42 "
15	20 46.7	−18 43	8 24 "	1 10.4 "	5 56 "
25	20 41.3	−19 04	7 42 "	12 26.0 "	5 10 "
Aug. 5	20 35.9	−19 27	6 55 "	11 36.9 P.M.	4 19 "
15	20 30.8	−19 46	6 11 "	10 52.6 "	3 34 "

SATURN.

June 25	10 09.9	+13 02	8 58 A.M.	3 54.0 P.M.	10 50 P.M.
July 5	10 13.4	+12 42	8 24 "	3 18.2 "	10 13 "
15	10 17.4	+12 19	7 50 "	2 42.8 "	9 36 "
25	10 21.6	+11 55	7 16 "	2 07.7 "	8 59 "
Aug. 5	10 26.6	+11 26	6 40 "	1 29.4 "	8 19 "
15	10 31.2	+10 59	6 07 "	12 54.8 "	7 42 "

URANUS.

June 25	13 24.5	− 8 15	1 37 P.M.	7 08.0 P.M.	12 39 A.M.
July 5	13 24.5	− 8 16	12 58 "	6 28.6 "	11 59 P.M.
15	13 24.8	− 8 18	12 19 "	5 49.7 "	11 20 "
25	12 25.5	− 8 22	11 41 A.M.	5 11.1 "	10 41 "
Aug. 5	13 26.5	− 8 29	10 59 "	4 28.9 "	9 59 "
15	13 27.7	− 8 37	10 22 "	3 50.8 "	9 20 "

NEPTUNE.

June 25	4 15.0	+19 39	2 35 A.M.	10 00.1 A.M.	5 25 P.M.
July 5	4 16.4	+19 43	1 56 "	9 22.1 "	4 48 "
15	4 17.6	+19 45	1 18 "	8 44.0 "	4 10 "
25	4 18.7	+19 48	12 39 "	8 05.1 "	3 32 "
Aug. 5	4 19.7	+19 50	11 57 P.M.	7 23.5 "	2 50 "
15	4 20.3	+19 51	11 18 "	6 44.9 "	2 12 "

THE SUN.

June 25	6 17.7	+23 23	4 17 A.M.	12 02.4 P.M.	7 48 P.M.
July 5	6 59.1	+22 45	4 22 "	12 04.3 "	7 46 "
15	7 39.9	+21 28	4 30 "	12 05.7 "	7 42 "
25	8 19.9	+19 34	4 40 "	12 06.3 "	7 33 "
Aug. 5	9 02.7	+16 52	4 52 "	12 05.7 "	7 20 "
15	9 40.6	+13 55	5 03 "	12 04.2 "	7 05 "

THE MOON.

June 20	8 42.9	+21 58	6 52 A.M.	2 46.9 P.M.	10 35 P.M.
25	12 42.5	+ 0 58	12 00 M.	6 26.1 "	12 40 A.M.
30	17 15.4	−22 40	6 00 P.M.	10 38.5 "	3 12 "
July 5	22 45.0	−13 23	10 34 "	3 47.7 A.M.	9 09 "
10	2 15.1	+ 9 22	12 17 A.M.	7 01.5 "	1 54 P.M.
15	6 37.9	+24 29	3 00 "	11 03.9 "	7 07 "
20	10 53.4	+12 32	7 47 "	2 59.1 P.M.	10 00 "
25	14 49.9	−12 54	1 09 P.M.	6 35.2 "	11 52 "
30	20 04.8	−23 24	7 00 "	11 29.6 "	2 01 A.M.
Aug. 5	1 57.1	+ 7 38	10 21 "	4 57.4 A.M.	11 42 "
10	5 26.3	+23 12	12 17 A.M	8 10.3 "	4 08 P.M.
15	9 50.1	+17 50	4 38 "	12 13.7 P.M.	7 40 "

CERES (1)

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
une 4	15 28.8	−13 02	5 23 P.M.	10 34 P.M.	3 45 A.M.
28	15 15.6	−14 02	3 41 "	8 48 "	1 55 P.M.

JUNO (3)

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
une 16	16 08.9	− 2 56	4 35 P.M.	10 27 P.M.	4 19 A.M.
uly 10	15 56.3	− 3 29	2 50 "	8 40 "	2 30 "
ιug. 3	15 54.6	− 5 03	1 20 "	7 04 "	12 48 "

[The above tables give local times for the Central Meridian and latitude ·44° 28′.]

Phenomena of Jupiter's Satellites.

d.	Central Time. h. m.			
June 15	10 21	P.M.	I.	Sh. In.
	11 14	"	II.	Ec. Dis.
	11 20	"	I.	Tr. In.
16	12 41	A.M.	I.	Sh. Eg.
	1 09	"	III.	Sh. In.
	1 40	"	I.	Tr. Eg.
	10 36	P.M.	IV.	Oc. Re.
	10 54	"	I.	Oc. Re.
17	10 43	"	II.	Tr. Eg.
19	10 33	"	III.	Oc. Re.
23	12 14	A.M.	I.	Sh. In.
	1 06	"	I.	Tr. In.
	1 48	"	II.	Ec. Dis.
24	12 41	"	I.	Oc. Re.
	9 52	P.M.	I.	Tr. Eg.
	10 10	"	II.	Tr. In.
	11 17	"	IV.	Sh. Eg.
	11 26	"	II.	Sh. Eg.
25	1 05	A.M.	II.	Tr. Eg.
	2 07	"	IV.	Tr. In.
27	2 01	"	III.	Oc. Re.
30	2 08	"	I.	Sh. In
	11 26	P.M.	I.	Ec. Dis.
July 1	2 26	A.M.	I.	Oc. Re.
	8 36	P.M.	I.	Sh. In.
	9 17	"	I.	Tr. In.
	10 56	"	I.	Sh. Eg.
	11 10	"	II.	Sh. In.
	11 37	"	I.	Tr. Eg.
2	12 30	A.M.	II.	Tr. In.
	8 53	P.M.	I.	Oc. Re.
3	9 47	"	II.	Oc. Re.
	11 16	"	III.	Ec. Dis.
8	1 21	A.M.	I.	Ec. Dis.
9	10 38	P.M.	I.	Oc. Re.
11	12 02	A.M.	II.	Oc. Re.
	9 47	P.M.	IV.	Tr. Eg.
14	8 46	"	III.	Sh. Eg.
	10 21	"	III.	Tr. Eg.
16	12 24	A.M.	I.	Sh. In.
	12 43	"	I.	Tr. In.
17	12 22	"	I.	Oc. Re.
	9 13	P.M.	I.	Sh. Eg.
July 17	9 31	P.M.	I.	Tr. Eg.
	10 48	"	II.	Ec. Dis.
19	8 37	P.M.	II.	Sh. Eg.
	9 06	"	IV.	Ec. Dis.
	9 09	"	II.	Tr. Eg.
21	9 07	"	III.	Sh. In.
	9 57	"	III.	Tr. In.
22	12 46	A.M.	III.	Sh. Eg.
	1 38	"	III.	Tr. Eg.
	11 39	P.M.	I.	Ec. Dis.
24	8 47	"	I.	Sh. In.
	8 54	"	I.	Tr. In.
	11 07	"	I.	Sh. Eg.
	11 14	"	I.	Tr. Eg.
25	1 23	A.M.	II.	Ec. Dis.
	8 32	P.M.	I.	Oc. Re.
26	8 30	"	II.	Tr. In.
	11 14	"	II.	Sh. Eg.
	11 25	"	II.	Tr. Eg.
29	1 07	A.M.	III.	Sh. In.
	1 13	"	III.	Tr. In.
31	1 30	"	I.	Oc. Dis.
	10 38	P.M.	I.	Tr. In.
	10 41	"	I.	Sh. In.
Aug. 1	12 58	A.M.	I.	Tr. Eg.
	1 01	"	I.	Sh. Eg.
	7 56	P.M.	I.	Oc. Dis.
	10 18	"	I.	Ec. Re.
2	7 30	"	I.	Sh. Eg.
	10 46	"	II.	Tr. In.
	10 57	"	II.	Sh. In.
4	8 04	"	II.	Ec. Re.
5	7 47	"	IV.	Ec. Re.
8	12 22	A.M.	I.	Tr. In.
	12 35	"	I.	Sh. In.
	9 40	P.M.	I.	Oc. Dis.
	10 46	"	III.	Ec. Re.
9	12 13	A.M.	I.	Ec. Re.
	9 08	P.M.	I.	Tr. Eg.
	9 24	"	I.	Sh. Eg.
13	9 39	"	IV.	Tr. In.
15	9 30	"	III.	Oc. Dis.
	11 25	"	I.	Oc. Dis.

Note.—In. indicates ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of satellite; Sh., transit of shadow.

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
June 22	*i* Leonis	5½	8 14	28	Star 1.5′ N. of Moon's limb		
26	80 Virginis	6	7 47	35	Star 0.5′ N. of Moon's limb		
July 1	λ Sagittarii	3	11 46	139	12 41	228	0 56
2	h^1 Sagittarii	6	12 18	40	13 14	308	0 56
2	h^2 Sagittarii	4½	12 26	81	13 44	265	1 18
5	τ^1 Aquarii *	5½	14 21	88	15 33	220	1 12
5	τ^2 Aquarii	4	15 49	44	17 03	270	1 14
11	B.A.C. 1206	6	14 50	45	15 47	266	0 57
24	95 Virginis	6	7 40	114	8 58	305	1 18
24	κ Virginis	4	12 05	186	12 18	213	0 13
28	63 Ophiuchi	6½	10 26	141	11 21	227	0 54
31	χ Capricorni	5½	8 14	32	8 57	310	0 43
31	φ Capricorni	5½	12 27	340	Star 2.0′ N. of Moon's limb		
Aug. 3	33 Piscium	4½	9 08	10	9 33	312	0 25
3	B.A.C. 17	6	11 23	36	12 23	272	1 00
7	B.A.C. 1119	6	14 26	48	15 35	256	1 09
9	*n* Tauri	5½	12 51	77	13 45	250	0 54

*Multiple star.

Phases of the Moon.

			Central Time. d	h m	
New Moon	1890	June	17	3 58	A. M.
First Quarter	"	"	25	7 54	"
Full Moon	"	July	2	8 23	"
Last Quarter	"	"	8	10 43	P. M.
New Moon	"	"	16	6 50	"
First Quarter	"	"	24	8 44	"
Full Moon	"	"	31	3 24	"
Last Quarter	"	August	7	8 19	A. M.
New Moon	"	"	15	10 20	"

Minima of Variable Stars of the Algol Type.

	R. A. h m s	Decl. ° ′	Approx. Central Times of Minima.
U Cephei	0 52 32	+81 17	July 1, 3 A. M.; 6, 3 A. M.; 11, 3 A. M.; 16, 2 A. M.; 21, 2 A. M.; 26, 2 A. M.; 31, 1 A. M.; Aug. 5, 1 A. M.; 10, 1 A. M.; 14, midn.
Algol	3 01 01	+40 32	July 9, 1 A. M.; 29, 2 A. M.;
λ Tauri	3 54 35	+12 11	Aug. 5, 4 A. M.; 9, 3 A. M.; 13, 2 A. M.
U Coronæ	15 13 43	+32 03	July 7, 2 A. M.; 13, 11 P. M.; 20, 9 P. M.
U Ophiuchi	17 10 56	+ 1 20	June 19, 3 A. M.; 19, 11 P. M.; 24 midn.; June 25, 8 P. M.; 29, midn.; 30, 8 P. M.; July 5, 1 A. M.; 5, 9 P. M.; July 10, 2 A. M.; 10, 10 P. M.; 15, 11 P. M.; 20, midn.; 21, 8 P. M.; 26, 11 P. M.; 31, 1 A. M.; 31, 9 P. M.; Aug. 5, 2 A. M.; 5, 10 P. M.; 10, 11 P. M.; 15, 11 P. M.

COMET NOTES.

Another Lost Comet. The veteran comet seekers, Swift and Brooks, oth report many unsuccessful searches for Brorsen's comet. Its course his year was favorable for its detection. Has this comet suffered the fate f Biela's comet?

***Comet 1890 I** (**Borelly**).* Ensign H. S. Chase, U. S. Navy, has computed he following elements of this comet from observations on dates Dec. 12 .nd 21, 1889, and Jan. 3, 1890 (*Astr. Jour.* No. 217):

$$T = 1890 \text{ Jan. } 26.260373 \text{ Wash. M. T.}$$
$$\left.\begin{aligned}\pi &= 208^\circ\ 15'\ 06.8'' \\ \Omega &= 8\ \ 17\ \ 11.2 \\ i &= 56\ \ 42\ \ 25.4\end{aligned}\right\}\ 1890.0$$
$$\log q = 9.430882;\ q = 0.269700$$

Comet 1889 I. The following ephemeris, from *Astr. Nach.* No. 2962, is continued from last month:

Berlin Midnight		α app. h	m	s	δ app. °	′	log. r	log. Δ	Brightness.
June	16	17	43	55	−6	51.2			
	18		41	42	6	51.0			
	20		39	30	6	50.9	0.7570	0.6754	0.85
	22		37	19	6	51.0			
	24		35	09	6	51.4			
	26		33	01	6	52.0			
	28		30	55	6	52.7	0.7621	0.6836	0.79
	30		28	52	6	53.6			
July	2		26	51	6	54.8			
	4		24	51	6	56.1			
	6		22	56	6	57.6	0.7671	0.6936	0.74
	8		21	02	6	59.3			
	10		19	11	7	01.1			
	12		17	23	7	03.1			
	14		15	38	7	05.2	0.7720	0.7052	0.69
	16		13	56	7	07.5			
	18		12	18	7	10.0			
	20		10	42	7	12.6			
	22		09	10	7	15.3	0.7769	0.7180	0.64
	24		07	41	7	18.2			
	26		06	16	7	21.2			
	28		04	54	7	24.3			
	30		03	35	7	27.5	0.7817	0.7318	0.59
Aug.	1		02	20	7	30.8			
	3		01	08	7	34.3			
	5	17	00	00	7	37.8			
	7	16	58	56	7	41.4	0.7864	0.7463	0.54
	9		57	55	7	45.1			
	11		56	58	7	48.9			
	13		56	04	7	52.8			
	15	16	55	13	−7	56.7	0.7911	0.6708	0.49

Mr. E. E. Barnard sends an interesting note on this comet.

***Comet 1890 ...** (**Brooks, March 19**).* Several sets of elements of this comet have come to hand. The following by Herr Bidschof (*Astr. Nach.*

No. 2966) depends upon observations dated March 21, April 3, and Ap
18

T	1890 June 1.1529 Berlin M. T	
ω	68° 36′ 10.7″	
Ω	320 17 18.6	1890.0
i	120 27 53.5	
log. q	0.281482; q	1.91197

From these elements Mr. O. C. Wendell has computed the ephem given below for June. The comet is easily picked up with a small telesc but will not become visible to the naked eye. It has a sharply defi nucleus of about the 10th magnitude, the nebulosity about it grow rapidly fainter. The tail is exceedingly faint, but can be traced for ab 1° from the nucleus.

Ephemeris of Comet a 1890, Brooks (March 19). From Bidsch elements as given in *A. N.* 2966, p. 239, I have computed the follow ephemeris:

Gr. M. T.	App. R. A. h	m	App. Dec. °	′	Log. r	Log. Δ
June 1.5	19	19.2	+58	30	0.2815	0.1963
2.5	19	12.0	59	18		
3.5	19	4.3	60	4		
4.5	18	56.2	60	48		
5.5	18	47.7	61	30	0.2817	0.1960
6.5	18	38.8	62	9		
7.5	18	29.5	62	46		
8.5	18	20.0	63	19		
9.5	18	10.0	63	49	0.2821	0.1988
10.5	17	59.6	64	16		
11.5	17	49.0	64	39		
12.5	17	38.3	64	59		
13.5	17	27.4	65	16	0.2829	0.2044
14.5	17	16.3	65	28		
15.5	17	5.2	65	37		
16.5	16	54.0	65	37		
17.5	16	43.0	65	44	0.2839	0.212
18.5	15	32.2	65	42		
19.5	16	21.6	65	37		
20.5	16	11.1	65	29		
21.5	16	0.9	65	18	0.2853	0.22
22.5	15	50.9	65	5		
23.5	15	41.2	64	50		
24.5	15	32.0	64	33		
25.5	15	23.1	64	12	0.2869	0.23
26.5	15	14.7	63	50		
27.5	15	6.8	63	25		
28.5	14	59.5	62	57		
29.5	14	52.9	62	27	0.2887	0.2
30.5	14	47.1	+61	55		

Harvard College Observatory, May 17, 1890. O. C. W

The Longest Known Duration of Visibility of a Comet, I 188 thought you would care to know that the comet discovered he tember 2, 1889, = I 1889, is still easily visible in the 12-inch refr the chances are that it will be followed until September, thus known visibility extend over two years. It is now nearly

months since its discovery. This of course carries its duration of visibility far beyond anything ever known before—five months longer than that of the great comet of 1811 which was the longest known previous to this.

The comet is now four hundred and twenty-seven millions of miles from the earth and five hundred and four millions from the sun. The apparent place of the comet this morning was

$$\alpha = 18^h\ 18^m\ 34.9^s \qquad \delta = -\ 7^\circ\ 21'\ 57''$$

at Mt. Hamilton, May 15, $14^h\ 50^m\ 21^s$ from filar micrometer comparisons with the star Schj. 6690. This gives the following correction to Berberich's ephemeris in *A. N.* 2962:

$$\text{In } \alpha, +\ 5^s: \qquad \text{in } \delta, -\ 1.9'.$$

See SIDEREAL MESSENGER for May, p. 227.

E. E. BARNARD.

MT. HAMILTON, MAY 16, 1890.

Comets of Short Period. A very interesting paper by M. Schulhof of Paris, entitled "Notes on Some Comets of Short Period," is contained in *Astr. Nach.* No. 2964. It is a discussion of the possible identity of several pairs of periodic comets by means of the criterion discovered by M. Tisserand and noticed in an article in this journal pp. 128 and 129. He finds the identity of Comet Finlay 1886 VII with Lexell 1770 more probable than that of Comet Brooks 1889 V with Lexell 1770. We may suggest that possibly both 1886 VII and 1889 V may be parts of Lexell 1770, as the latter may have suffered disruption by passing through Jupiter's system of satellites in 1779, just as the Brooks comet seems to have been divided in 1886.

Mr. Schulhof also discusses the possible identity of comets Finlay 1886 VII and De Vico 1884 I, Denning 1881 V and Pigott 1783, Blanpain 1819 and Grischow 1743, Coggia 1873 VII and Pons 1818 I, Biela and Pons 1818 I, Winnecke and Helfenzrieder 1766 II., reaching a certain negative conclusion in the case of only the second pair.

Annular Eclipse of the Sun.—An annular eclipse of the sun will take place on June 17. It will not be visible in America, the path of the annular eclipse beginning in the Atlantic ocean, passing across Northern Africa, the Mediterranean Sea, Turkey, Persia, Hindostan, ending in Siam.

Lunar Appulse. Forty-five minutes after midnight of June 2, the moon will pass so close to the edge of the earth's shadow that it is doubtful whether the edge of the moon will enter the shadow or not. The angle of position of the point of approach from the north point of the disk is 167° toward the west.

New Planetoids. Two new planetoids were discovered on April 25 by Palisa at Vienna. Their numbers are 291 and 292. Professor Krueger thinks that No. 292 is probably a rediscovery of Scylla, No. 155, found by Palisa in 1875. The two were very near together, the position of one being on April 25, R. A. $14^h\ 21.1^m$, Decl. $-11^\circ 06'$; that of the other R. A. $14^h\ 19.6^m$, Decl. $-10^\circ 40'$. They were discovered independently on April 26 by Charlois at Nice. Another of the 13th magnitude was discovered by Charlois May 20.5784, in R. A. $16^h\ 20^m\ 55^s$, Decl. $-22^\circ 39' 02''$.

Solar Prominences for April.—Number of observations, 14. Number of prominences, 43. Mean, 3¼. Greatest number in one day, 6 on the 29th. Least number in one day, 1 on the 1st. Highest prominences, 54″ on 20th and 28th.

DISTRIBUTION IN LATITUDE.

	E.	W.		E.	W.
Between 0 A.M. 10	4	2	Between 0 A.M. —10	1	2
+ 10 " 20	4	..	+ 10 " 20	..	3
20 " 30	..	..	20 " 30	2	1
30 " 40	..	..	30 " 40	..	..
40 " 50	..	..	40 " 50	.	..
50 " 60	..	..	50 " 60	..	2
60 " 70	..	..	60 " 70	..	2
70 " 80	..	..	70 " 80	4	..
+ 80 " 80	7	2	+ 80 " 90	3	4
				25	18

Camden Observatory.

Smith Observatory Observations. The following solar observations have been made with helioscope, except when otherwise specified. Those of April 16th were made by Mr. F. M. Jack.

On 12th and 13th May the sun was glimpsed for a moment only, although watched all day, but it was impossible to count spots accurately.

1890.	90° Mer. M. T.	Groups...	Spots.....	Faculae..	Seeing.	Remarks.
12 April.	1 P. M.	4	10	1 gr.	Good.	Fac. about 3d gr. spots.
13 "	1 "	0	0	0	Clouds.	Nothing distinct visible.
14 "	11.15 A. M.	0	0	1	Poor.	Gran. difficult.
15 "	11.45 "	1	3	1	Fair.	Fac. disturbance around spots.
16 "	10.30 "	1	3	1	Very good.	Gran. good.*
17 "	12 M.	0	0	1	Fair.	Gran. good.
18 "	11.20 A. M.	0	0	1	Poor.	Gran. fair.
19 "	2.15 P. M.	0	0	2	Bad.	Gran. dif.; limb very unsteady.
20 "	12 M.	0	0	0	Poor.	Larger gran. fair.
21 "	11 A. M.	0	0	0	Fair.	Light haze too indistinct for faint spots.
22 "	11.30 "	0	0	2	Good.	Fac. faint on E. and W. limbs.
23 "	11.30 "	0	0	0	Poor.	Gran. dif.
24 "	12 M.	0	0	0	Poor.	Gran. dif., limb unsteady.
25 "	11.30 A. M.	0	0	0	Bad.	Seeing almost impossible; haze.
27 "	12.30 "	0	0	0	Bad.	Gran. indistinct.
28 "	2 P. M.	1	1	0	Fair.	Small and indistinct.*
29 "	12.15 "	2	4	0	Poor.	2 masses nuclei, 2 tiny veiled spots between.
30 "	9.15 A. M.	2	12	0	Poor.	1 faint veiled spot between groups.
1 May.	11.30 "	0	0	0	Bad.	Impossible to make out anything.*
2 "	5.30 P. M.	0	0	1	Good.	Gran. good.
3 "	3.00 "	0	0	1	Fair.	Fac. near S. W. limb.
6 "	2.30 "	0	0	0	Bad.	Clouds: indistinct.
7 "	11.45 A. M.	1	2	1	Good.	Spots very minute; Fac. E. limb.
8 "	2 P. M.	2	5	1	Good.	Fac. around spot centres.
10 "	2.30 "	2	12	0	Very good.	Small gran. very distinct.
11 "	3.30 "	3	17	2	Very good.	Fac. near N. E. limb; and W. gr. spots.
12 "	11.54 A. M.	2	?	0	Bad.	Single glimpse through clouds; gen. app. unchanged.
13 "	1.30 "	2	?	0	Clouds.	Groups fainter, unable to count spots.
14 "	5.20	0	0	2	Good.	Fac. near E. and W. limbs.
15 "	11.45 "	0	0	0	Poor.	Gran. fair.

* Projection on 20 cm. circle.

Smith Observatory, Beloit College,
May 15th, 1890.

CHAS. A. BACON.

Associate Solar Phenomena. The accompanying table has in the first column the dates on which faculæ appeared by rotation on the sun, as determined by the observations published in THE SIDEREAL MESSENGER and the Monthly Weather Review, supplemented in one or two instances by the observations of the writer. In the second column are indicated the extent of magnetic perturbations as shown by the declination magnetograph at the Naval Observatory, Washington. In the third column are given the numbers of stations daily reporting auroras to the signal service bureau, and in the fourth column the extent of thunder-storms as described in the Monthly Weather Review.

This table is not intended to give anything more than a concise summary of such information as is at hand at the present writing for thr months named, so as to indicate the points with reference to which furthee observations may be desirable. In general it appears that when solar disturbances are at or near the eastern limb there is a manifest increase in auroras and magnetic storms. The exception on Jan. 20th is more apparent than real, as is shown by the fact that at the next return on Feb. 14th and 15th groups of faculæ were visible at the eastern limb, and there was a recurrence of magnetic perturbations and auroras. The other exceptional case on Feb. 24th is of a different character. On this date there was no increase in magnetic perturbations and auroras, although faculæ appeared by rotation. Thunder-storms, however, attained their maximum, which corresponds to what has been observed in many other instances indicating that there is a reciprocal relation between these phenomena, the one taking the place of the other at times.

It is noteworthy also that the maxima of auroras on Jan. 17th and following days corresponds to that on Feb. 11th and following days at an interval corresponding precisely to the time of the rotation of the sun. Such periodicity is very common.

Date.	Solar Condition.	Magnet.	Auroras.	Thunder-storms.
January, 1890.				
1		Calm.		8 States.
2	Faculae by rotation.	Much.	1 Station.	8 States.
3		Much.	1 Station.	1 to 4 States.
4		Slight.		1 to 4 States.
5		Calm.		1 to 4 States.
6		Slight.		1 to 4 States.
7		Calm.		1 to 4 States.
8		Calm.		1 to 4 States.
9	Faculae by rotation.	Moderate.		None.
10	Faculae by rotation.	Moderate.		1 to 4 States.
11		Calm.	1 (Corona)	1 to 4 States.
12		Calm.		11 States.
13		Slight.		1 to 4 States.
14		Calm.		1 to 4 States.
15		Calm.		1 to 4 States.
16	Faculae by rotation.	Calm.		1 to 4 States.
17		Much.	12 Stations	None.
18		Much.	6 Stations.	1 to 4 States.
19		Calm.		8 States.
20		Much.	2 Stations.	5 States.
21		Slight.	5 Stations.	None.
22		Slight.		1 to 4 States.
23	Faculae by rotation.	Slight.		None.
24		Calm.		1 to 4 States.
25		Calm.		1 to 4 States.
26		Calm.		None.
27		Calm.		None.
28	Faculae (Jan. 2nd area)	Slight.	1 Station.	1 to 4 States.
29		Calm.		1 to 4 States.
30		Calm.	1 Station.	None.
31		Slight.	2 Stations.	1 to 4 States.

Date	Solar Condition	Magnet	Auroras	Thunder storms
February				
1		Calm	1 Station	1 to 3 States
2	Faculae by rotation	Moderate		1 to [illegible] States
3		Moderate		None
4		Calm		5 to 11 States
5		Slight		None
6	Faculae (Jan. 9th area)	Calm	1 Station	5 to 11 States
7		Slight		None
8		Slight		5 to 11 States
9		Calm		1 to 5 States
10		Calm		1 to 5 States
11	Faculae (Jan. 16th area)	Moderate	7 Stations	1 to 5 States
12		Slight		1 to 5 States
13		Slight	1 Station	5 to 11 States
14	Faculae by rotation	Much	6 Stations	5 to 11 States
15	Faculae (See Jan. 20th)	Moderate	1 Station	None
16		Slight		None
17		Much		5 to 11 States
18	(Jan. 23rd area)	Much	1 Station	
19		Moderate		14 States
20		Moderate	1 Station	5 to 11 States
21		Slight		1 to [illegible] States
22		Calm		1 to 4 States
23		Calm		5 to 11 States
24	Faculae (Jan. 28th)	Calm		20 States [illegible]
25		Calm		24 States [illegible]
26		Slight		19 States
27		Calm		5 to 11 States
28		Calm		

M. A. V.

Carleton College Sun Spot Observations. (Continued from page 230.)

Date	Central Time	Gr.	Spots	Fac.	Obs.	Remarks
April 22	2 20 P. M.	0	0	0	C. R. W.	
23	2 10 "	0	0	0	"	
24	12 20 "	0	0	0	"	
25		0	0	1 gr.	H. C. W.	
26	12 20 "	0	0	1 gr.	C. R. W.	
28	10 30 A. M.	1	2	0	H. C. W.	
29	12 30 P. M.	1	15	0		
30	12 20 "	8	1	1 gr.	C. R. W.	Two parts to the group connected by a dark line.
May 1	12 30 "	1	1	1 gr.	"	
2	12 25 "	0	0		"	
3	4 10 "	0	0	1 gr.		
7	12 15 "	0	0	1 gr.	H. C. W.	
10	12 30 "	8	1	1 gr.	C. R. W.	Two large spots. Faculae near the spots.
14	2 05 "	0	0	0	"	
21	1 40 "	2	2	2 gr.	H. C. W.	
23	12 30 "	1	2	0	C. R. W.	
24	1 30 "	0	0	0	H. C. W.	
26	10 00 A. M.	1	2	1 gr.	C. R. W.	
28	3 50 P. M.	0	0	1 gr.	"	
29	12 30 "	0	0	1 gr.	"	

Julian Day. In No. X. of Vol. 18 of the Annals of Harvard College Observatory, we notice a useful table which shows how the Julian day affords a convenient means of determining the interval in days between any two calendar dates. The table is arranged to determine the Julian day of any date in the nineteenth century, and has been found, in practice, a more convenient form than that usually employed.

Mr. Tebbutt's Observatory. The reports of Mr. Tebbutt's Observatory for the years 1888 and 1889 have been received. Their contents describe the Observatory building and instruments, give the geographical position of the Observatory and some account of the Meridian and extra Meridian work, meteorological observations, publications, the library, personal establishment and statement of proposed work for the present year. Though not large volumes these reports show useful astronomical work.

NEWS AND NOTES.

Subscribers will please remember that this journal will not be published for the month of July. The next number will appear for the month of August or September.

Fourth Annual Report, Henry Draper Memorial, Harvard College Observatory. The first investigation undertaken as a memorial to Dr. Henry Draper was the formation of a catalogue of about 10,000 stars north of —25°, and in general brighter than the seventh magnitude, by the aid of the Batche telescope, eight inches aperture and 44 inches focal length. This investigation is nearly completed. The catalogue and about half of the table giving the details of the observations are already in type. Notes giving the peculiarities of the spectra are completed and in the hands of the printer.

The second investigation relates to the spectra of fainter stars. Photographs with exposures of one hour have been made in nearly all parts of the sky north of —25°, and furnish material for a discussion of spectra of stars brighter than the ninth magnitude. Several thousand of these spectra have been identified and measured.

The expedition under the direction of Mr. S. I. Bailey, which went to Peru, South America, last spring, chose a position on a mountain 6,500 feet high, about 20 miles east of Lima. During the first six months the weather was good, and about 1,300 photographs were obtained, and each of four principal researches were about half completed. The first series of photographs taken by the Batche telescope furnish charts of the entire sky south of —25°, using exposures of ten minutes. All stars brighter than the tenth magnitude will thus be photographed. A second set of charts having exposures of an hour cover the same regions, and include stars brighter than the fifteenth magnitude. This interesting report then describes a number of the more remarkable southern objects, such as the nebula around η Argus, the Trifid nebula, N. G. C. 6533, etc. The most important work of the eleven-inch telescope has been the study of the spectrum in which the K line is occasionally double. In the case of ζ Ursæ Majoris this appeared to take place at intervals of fifty-two days. An explanation of this curious phenomenon is furnished by supposing that the star is a close binary the maximum velocity of whose components is about one hundred miles per second. The spectrum of β Aurigæ exhibits a similar peculiarity. The maximum separation indicates a relative velocity of one hundred and fifty miles per second and it occurs with great regularity. A period of four days is indicated, and a nearly circular orbit. This corresponds to a distance between the components of about 8,000,000 miles, and a combined mass of two and three tenths times that of the sun. This report has as a frontispiece a fine lithograph plate showing the spectrum of this last named star with K line both single and double.

Bright Streaks from the Craters of the Moon. In the May number o *Knowledge*, Editor A. C. Ranyard has an article on the great bright streaks which radiate from some of the larger lunar craters. This paper refers to

another of like interest published last October by Mr. Ranyard in the same journal giving reasons to support the view that the surface of the moon is covered with snow, or ice and hence the unchanging color so commonly reported by all observers. Starting with this view Mr. Ranyard discusses the possible causes of these radiating streaks. He has to aid him a fine full page illustration of one of the photographs of the moon taken by the great refractor of Lick Observatory. He supposes, as shown in the former article, that the polar caps, like those seen in Mars, have extended towards the equator, and there met; that the great whiteness of the higher portions may thus be accounted for; that the darker color of lower levels may be due to the mixture of rock, debris and moving snow and ice. In these articles the author gives the different views of astronomers commonly held, and to them adds the above as suggestions rather than definitely formed opinions.

The three following paragraphs are from the Publications of the Astronomical Society of the Pacific, No. 8. (May 31, 1890.)

Note on Photographing the Dark Part of the Moon. It is found by experiments made on the evening of April 21 that the dark part of the moon, when the moon's age is 2.9 days, can be photographed with the 12 inch equatorial with a seed 26 plate in 20 seconds the complete outline of the dark part just showing with this exposure. With 40 seconds and 70 seconds the dark part was conspicuous and details on it were clearly shown. E. E. B.

Copies of Photographs taken at the Lick Observatory—How to obtain them. The Director of the Lick Observatory has been authorized to furnish copies of some of the negatives taken at Mount Hamilton to certain photographers, in order to make such copies available generally. Copies of some of our negatives have been furnished to quite a number of firms accordingly. Some of these firms (I. W. Taber, 8 Montgomery Street, San Francisco; Hill & Watkins, Santa Clara Street, San Jose, and Gayton A. Douglas & Co., 185 Wabash Avenue, Chicago,) are prepared to furnish prints, enlargements and lantern slides from such negatives as they now have. Other negatives will be furnished to them from time to time.

E. S. H.

Companion of Sirius.

P = 359°.6	D = 4″.17	1890.252
361 .6	4 .20	.259
256 .8	4 .19	.304
359 .7	4 .19	1890.27

These measures were made with the 36-inch equatorial. S. W. B.

Observatory of Paris. The annual report of the Director of the Observatory of Paris for the year 1889 has just come to hand. It contains an account of the Photographic Congress which met at the Observatory in September, the work which has been done with various instruments by the large corps of observers, a description of the great *Equatorial Coude*, 59 feet focal length, 23.6 inches aperture and various other matters of interest.

The Iowa Meteor. Late in the afternoon of Friday, May 2, a brilliant meteor was seen in Northern Iowa, Southern Minnesota and South Dakota. At Northfield the meteor was observed S. 30° W. at a height of about 40°, and disappeared near the horizon, behind trees, S. 20° W. Its duration was about 5^s. Intensely bright, although no distinct head could be seen, but part of its path was brighter than the moon. Its motion appeared to be in the arc of a great circle passing through the north pole, with a length of about 30°. Time of observation was $5^h\ 10.5^m$.

From Alta, Iowa, Mr. David E. Hadden reports: A brilliant meteor was observed here about 5.10 o'clock, Central time, on the afternoon of May 2d. It appeared to emanate from a point in altitude 35°, azimuth 170°, and traveled rapidly in a nearly straight line to a point in altitude 10°, azimuth 250° (approximately,) when it disappeared. Although in full sunlight and a cloudless sky, the meteor was a conspicuous object, being unusually large and of an intense greenish white color at first, changing at disappearance to a bright red. It left a long trail, which remained distinctly visible for over 45 minutes. No sound was heard to accompany it."

At Sioux City, Iowa, it was seen at $5^h\ 45^m$, passing northwest of the city. It appeared at an elevation of 25°, seemed to burst three times, and then disappeared. The time of its appearance at Mason city was reported at $5^h\ 15^m$, moving nearly east, and the report it made in passing through the air is likened to that of cannon by the people who heard it. Its path was a long streak of fire and smoke. People were greatly excited and sought to find its fall. At Algona the meteor was reported to pass at 5^h P. M., with a noise like thunder. At Wells, Minnesota, it was seen, and the noise was like thunder. It was very bright, although the sun was shining at the time. A streak of blue smoke was left behind it. The meteor was plainly seen at Lake Benton, Currie, Sioux Falls, Forest City, Britt, Emmetsburg, Ruthven, and a large number of other places. There seems to be little doubt that there were several explosions of the meteor while over Northern Iowa, and possibly some in Southern Minnesota if reports can be relied on.

The experience of a representative of the University of Minnesota in attempting to secure some of the precious fragments of this brilliant visitor has been matter of amusing conversation and general interest in literary and legal circles hereabouts for the last few weeks. The representative above referred to soon found the locality, a few miles from the south line of Minnesota, where some pieces of the meteor had fallen, on a farm in the possession of a man by the name of Anderson, who doubtless esteemed his prize of some value. Others interested in buying the fragments were also soon at the same place with the determined purpose of becoming owners of all aerial stones that Mr. Anderson or any one else had to dispose of by auction or otherwise. Very soon the interest ran so high in securing the largest piece of the meteor that bidding between two persons ran up to over one hundred dollars, and the representative of the University of Minnesota was the successful competitor. This large fragment was boxed and taken to the nearest railroad station, and the aerolite hunters went in search of more fragments. In the mean time new and unforseen difficulties arose. Mr. Anderson, who had sold the meteor and received the money,

was only lessee of the ground where the meteor had fallen, and not the owner of it, so the rightful owner, with officer and papers suddenly appeared at the station where the meteor was lodged for transportation and took possession of this piece of Iowa property, and immediately made away with it. The Minnesota scientist with alacrity secured Minnesota council, and thus legally armed renewed the exciting contest. After the necessary formal and official parley the meteorite and its purchase money were taken possession of by the representatives of the law, and a case will soon be argued in court to decide whether a lessee of land or the fee owner has title to an aerolite that has fallen during the time of lease. This case parallels a similar one mentioned in Langley's New Astronomy page 187.

While this question is being settled, it will be of interest to scholars in this branch of astronomy to know that Professor Weld, of Iowa State University, is industriously collecting all data he can to determine the orbit of the meteor, and its physical characteristics. Any information to aid him in this will be gratefully received.

Origin of Aerolites. Since the fall of the fragments of the Iowa aerolite on the afternoon of May 2, considerable has appeared in current local newspapers pertaining to the origin of aerolites and phenomena accompanying them within the range of observation. We are indebted to Mr. D. G. Parker of Albert Lea, Minn., for some articles bearing on this theme that we would not otherwise have seen. With him we are surprised that any prominent scholar should now hold that the origin of aerolites is from the moon. Some writers, as Mr. Proctor, have held that meteors including meteorites, aerolites and other bodies named as belonging to this common family, are due, probably, to the eruptive force of the sun. But this view, plausible as it may seem, is not commonly held by astronomers of the present day. As Mr. Parker claims, in a well written article appearing May 22 in the *Freeborn County Standard*, meteors are independent bodies moving in orbits of their own in space, that these dark bodies are abundant in the interplanetary spaces, that those within the near range of solar or planetary attraction move with great velocity, that many swarms of them follow well known orbits, and that, in general, their origin is undoubtedly the same as that of other celestial bodies. For authorities the reader is referred to Young's General Astronomy, Chambers' Handbook of Astronomy, Edmund Beckett's Astronomy without Mathematics, Ball's Story of the Heavens, Winchell's World Life and Comparative Geology, Langley's New Astronomy, and many others that might be easily named.

United Astronomical Research. It is a pity that all available means for the improvement of American Astronomy are not put to wise and productive use. The number of small telescopes in all parts of the country, the host of amateur observers who are willing to devote time in useful work, and the general public interest in popular astronomy are enough to awaken thought and desire to devise some plan by which so much valuable energy might be turned into proper channels, instructed and utilized. How easy it would be for anyone having a small telescope to devote himself to some one line of observation, and conscientiously persevere in securing and

making a complete record for some period of time suitable for the study. Such a course would certainly increase interest in reading and knowing all that could be learned in the special line of observation, and very likely bring to the attention, some new things about it, that may have escaped the notice of older and wiser ones in science.

There is not a single line of astronomical study that might not be profitably pursued in such a plan as this. The simple question is, are the young or amateur observers willing to undertake some simple line of observation and persistently follow it, for the sake of making a complete record of what may be seen and what ought to be recorded? In reply to this we fancy some student is ready to say that he would gladly undertake such work if he knew what to do or how to do it. If there are such we desire to know their names, what kind of a telescope they have, and if they have tried any regular observing. It is not necessary that an observer should devote a *great* deal of time daily, but it is important that all such work should be done well, systematically and thoroughly. We do not see why a score of young observers could not be continually doing useful work, and thereby gaining for themselves knowledge, facility and skill in astronomy that can not possibly be secured in any other way. If a plan like this interests any of our readers they are respectfully asked to correspond with us concerning it. Possibly this matter may be considered of sufficient importance to find place in the councils of the proper section of the American Association for the Advancement of Science at its next meeting in Indianapolis. The further question of unifying the regular astronomical work of the United States is certainly a subject that ought to claim the attention of Astronomers and others directly or indirectly interested.

Lightning Spectra. Mr. W. E. Woods of Washington, D. C., under date of May 16, writes of his use of a Browning's Pocket Spectroscope in the study of the spectra of lightning during a thunder storm. In several instances he observed the spectra of flashes which appeared as bright lines superposed on a faint continuous spectrum. In each case, when the continuous spectrum was bright enough to be seen, shaded flutings were visible. An interesting diagram of observations accompanied Mr. Wood's letter. We hope to be favored by further studies of this kind.

Reversed Curvature of Shadow on Saturn's Rings. Elsewhere will be found an article by Mr. Aldro Jenks on the reversed curvature of the shadow on Saturn's rings. There is probably no doubt of the correctness of the observations reported, for the same thing has been seen by experienced observers before. The theory proposed by Mr. Jenks for the explanation of the same is novel, and without any analogy to support it, yet his is the honest effort of an amateur to account for a phenomenon before not even attempted so far as we know.

Algol System. In a communication to the MESSENGER sent from this place last month, I made a suggestion that the variability of Algol's period might be due to an orbital motion of the Algol system, as now almost established, around a central invisible body.

Before my article could have reached you there was already in type, what I now read in THE MESSENGER with intense interest Professor Vogel's announcement of the proper motion of the Algol system This is precisely the information I hoped to obtain as already stated, many years ago

Now if the motion of Algol toward us is coincident with the shortening of its period of variation, it may be expected that when, in the course of the long observed fluctuations, this period shall lengthen Algol will be found to be receding from us. Let this be proved, and the existence of a revolution around a central controlling force seems to be an inevitable conclusion

WM. CURTIS TAYLOR

Tacoma, Wash. May 8, 1890

Photographic Notes. *The Observatory* for May contains a paper by A A Common on "The Photographic Chart of the Heavens" In discussing means of securing uniformity of development of plates Mr Common recommends a system of squares similar to that introduced by Capt Abney for measuring the photographic intensity of light As to the position of the plate it is suggested that it should be in the middle of the tube of the photographing telescope

The same number of *The Observatory* states that MM Henry strongly recommend the following method for preventing halos about the photographic images of bright stars "Coat the back of the plate with normal collodion containing a little chrysoidine. This is of almost the same refractive index as glass, and completely suppresses halos even with the brightest stars."

Monthly Notices for March publishes an article by Mr E E Barnard "On Some Celestial Photographs Made with a Large Portrait Lens at the Lick Observatory" Mr Barnard attached such a lens of 5.9 inch aperture to a 6½ inch equatorial, using the equatorial as a following telescope Exposures were made on the Milky Way the Pleiades, and the Great Nebula of Andromeda In regard to the results Mr. Barnard writes "For many years I have observed in my comet seeking a most remarkable small inky black hole in a crowded part of the Milky Way. Not only is the black hole clearly shown in this negative, but the entire cloud like formation about it in which myriads of stars are all faithfully depicted The exceeding beauty of a glass positive from this plate is beyond description. . I have made reduced copies of the above negatives. The result is striking In the Milky Way pictures, the cloud-like masses of stars stand out more boldly, and their forms are more definite than in the original Reduced in this way the picture of the region of the Andromeda nebula is singularly beautiful, and it shows in a most remarkable manner the peculiar structure of that part of the heavens The intricate arrangement of the stars in rings and segments are thus shown as nothing else can show them."

Mr Isaac Roberts' photographs of clusters 33 and 34 H VI Persei in which he finds no trace of nebulosity, suggest to him a possible "classification of some of the stages in the evolution of the universe" through a study of the different nebulosities of clusters.

Bulletin No 13 U S Scientific Expedition to West Africa. Under date of March 13, 1890, Professor Cleveland Abbe, of the United States Signal Service, member of the Scientific Expedition, under Professor Todd issued Bulletin No. 13, with title, "Localities of Scientific Interest in St. Helena In it are found references to the work of Edmund Halley (1676) who compiled the first catalogue of southern stars, 341 in number, and who observed a transit of Mercury Nov. 7 1677 Also are given references to work done by Abraham Sharp, Maskelyne and Waddington, John MacDonald, Captain Henry Foster, and a dozen others who have made useful contributions to science from this historic island

Gainesville Meteor. A meteor weighing several hundred pounds fell at Gainesville, Texas, in the yard of S. P. Hargis, who lives near here, on the evening March 19. The meteor had the appearance of a huge flint rock, and its flight through the air caused a roaring sound which was heard several seconds before it struck the earth and which resembled distant thunder. It exploded with a report like a cannon while still in the air, and fragments of the stone were scattered for rods around. The main body of the strange visitor struck about fifty feet from Mr. Hargis' house with such force as to imbed itself deeply in the ground.—*Chicago Tribune.*

BOOK NOTICES.

A HAND-BOOK OF DESCRIPTIVE AND PRACTICAL ASTRONOMY, by George F. Chambers, F. R. A. S.
II. INSTRUMENTS AND PRACTICAL ASTRONOMY. Fourth Edition. Oxford: At the Clarenden Press. 1890, 8vo, pp. 558.

The first volnme of the fourth edition of Chambers' Hand-book of Descriptive and Practical Astronomy was published in September, 1889, and notice of it has already appeared, with brief explanation of the plan on which the entire revision of the the third edition of this important hand-book would go forward. The second part, which is titled "Instruments and Practical Astronony," is now before us.

A fine Woodbury-type of the new 30-inch refractor of the Pulkowa Observatory forms the frontispiece. The mounting of the telescope, by Repsold & Sons, and the various appliances for work, in the great dome, show with good advantage.

The contents of this part are divided into four books, numbered consecutively from similar divisions in the first part. Book VII. treats of practical astronomy, discussing, in separate chapters, the following topics, viz.: the telescope and its accessories; telescope stands; the equatorial; the transit instrument; the sextant; miscellaneous astronomical instruments; the observatory; practical hints on the conduct of astronomical observations; history of the telescope.

Book VIII. presents spectroscopic astronomy and the topics are spectroscopy as applied to the sun; as applied to planets and comets; to stars and nebulæ; maps of the spectrum.

Book IX. is devoted to astronomical photography.

Book X. presents chronological astronomy, (1) in respect to time generally; (2) subdivisions of time; (3) the almanac; (4) cycles.

Book XI. gives a brief sketch of the history of astronomy.

Book XII. treats of astronomical bibliography, giving a list of published star catalogues and celestial charts, also a list of books relating to reading on astronomy.

Book XIII. contains a series of useful astronomical tables, followed by a vocabulary of definitions, and an index designed for use in connection with the table of general contents.

It is not necessary to speak of the treatment of the various topics of this work in detail, for those already acquainted with former editions, because they know of the thorough study the author has made of the whole subject and the varied sources of general information which he has put under tribute to make a complete hand-book for use in astronomy. But, for those of our readers who are not acquainted with Professor Chambers' books, something ought to be said about the details of this book, to aid in a proper judgment of it. Any part of this volume might be chosen for this purpose with equal propriety, and so we call attention to the first chapter, whose title is "Telescope and Its Accessories." The order of this theme is as follows: Two kinds of telescopes, reflecting, the Gregorian reflector, the Cassegrainian, the Newtonian, the Herschelian, Lord Rosse's large reflector, Nasmyth's reflector, Browning's mountings for reflectors, adjustments for reflectors, refracting telescopes, refractors and reflectors compared, spherical aberration, chromatic aberration, tests for both, theory of

achromatic combinations, tests of a good object glass the dyalite, the Gregorian retractor, eye pieces, the positive eye piece, the negative, formulæ for calculating the focal lengths of equivalent lenses, Kellner's eye piece, the Barlow lens, the terrestrial eye piece, the pancratic terrestrial eye piece, Grubb's prismatic terrestrial eye piece, Ramsden's dynamometer, Berthon's dynamometer, Dawe's rotating eye piece, the diagonal eye piece, Dawe's solar eye-piece, Hilger's solar eye piece, the polarizing solar eye-piece, Airy's eye piece for atmospheric dispersions, micrometers, the reticuled micrometer, the parallel wire micrometer, the position micrometer, measurement of angles of position, Grubb's duplex micrometer, bright wire micrometer, Bidder's micrometer, Burnham's micrometer, the double image micrometer, the ring micrometer, the square bar micrometer, the zone reticule, sliding piece telescope tubes.

Forty-seven pages are devoted to this chapter, and thirty-eight cuts appear in connection with the descriptive matter. They are neat in design, clear, well finished, without the idea of extra or far fetched embellishment but intended to serve the definite purpose of illustrating what the author is talking about. This art of choosing and designing plates and cuts to illustrate scientific thought and work is so often the weak point in good books that ability in any ought to be recognized and commended. In this chapter and throughout the book the author has given deserved attention to and illustration of American work in astronomy, and we believe this volume will find a large sale on this side because it is so well adapted to the wants of a large number of students in astronomy who either own or have access to and use astronomical instruments. Professor Chambers is to be congratulated in the success he has already realized in the revision of this, the leading handbook of astronomy in the English language.

OUR INHERITANCE IN THE GREAT PYRAMID. With Twenty-five Explanatory Plates, Showing the more Crucial Parts of this really Anti-Egyptian and most Primeval Structure, in Plan, Elevation, and Section. By C. Piazzi Smyth, F. R. S. E., F. R. A. S., Late Astronomer Royal for Scotland. London, Messrs. Charles Burnet & Co., Publishers, 9 Buckingham Street, Strand, 1890. Fifth Edition. 452 pp.

We have not before seen this book, though it has passed through its fifth edition, and has long been well known in scientific and literary circles, in both the Old World and the New. This edition retains the whole of the twenty five fine and instructive plates of the former editions, but the letter-press has been reduced from 664 to 445 pages, and yet there have been incorporated into the latter 31 pages of appendices, mostly by new authors, showing rather forcibly how the sacred and scientific pyramid theory of John Taylor is now being pursued, not only by Anglo-Saxon, Anglo-Israel, North American and Great Britain, but also by Belgium in the use of the French language.

The plates, before referred to, are full-page, printed in colors, and precede the text, and very helpfully illustrate the details of the Great Pyramid which has been so carefully studied by many interested scholars to learn all that might be known about its strange and wonderful symbolism. The book is divided into five parts, presenting, in order, the geography and exterior of the Great Pyramid, history and interior of it, national weights and measures, also those of the Great Pyramid, a meaning in its symbols beyond that of ordinary science, and, finally, the personal and the future of the Great Pyramid.

The detailed study of this book will interest any one at all acquainted with the curious structure of this pyramid, the greatest of Egypt's great wonders. So much information has been collected, and so wide a range of scholarship has contributed to it, that there is little wonder that it has received general attention in the past. The appendices, which are mostly new matter, bring these observations down to the present year. And the book, as a whole, gives probably the best and most complete knowledge of its theme to be found in print anywhere.

THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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STEREOSCOPIC OBSERVATIONS ON BINARY STARS.

W. H. S. MONCK.

For THE MESSENGER.

Mr. A. A. Rambaut, in a paper which appeared in the *Monthly Notices* of the Royal Astronomical Society for March, 1890, shows that if we know the elements of the orbit of a binary star and the spectroscopic velocity of both components in the line of sight its parallax may be computed by the formula

$$\pi V = A + B \cos (\theta - \lambda)$$

Where π is the parallax, V the relative velocity of the two components in the line of sight, and A and B have the following values

$$A = \frac{lae \sin \gamma \cos \lambda}{P \sqrt{1 - e^2}}$$

$$B = \frac{la \sin \gamma}{P \sqrt{1 - e^2}}$$

Where l is the earth's velocity in miles per second (which may be taken at 18.5), P is the period of the binary couple in years, γ is the inclination, λ is the angle between the line of nodes and the major axis, and θ is the true anomaly at the date of the observation.

As it is rarely possible to obtain good spectroscopic observations on the velocities of both components, I propose in the present paper to try how far this defect can be remedied by several observations made on the brighter component at different points of the orbit. For this purpose I assume that the proper motion of the binary pair in the line of sight does not change during the period over which the observations extend, and that the observed changes of velocity are consequently due to the orbital motion of the principal star.

Now if v_1, v_2 represent the orbital velocities of the two components in the line of sight, we have evidently

$$V = v_1 + v_2$$

But if m_1, m_2 represent the masses of the pair, v_2 is $= \frac{m_1}{m_2} v_1$

and $V = (1 + \frac{m_1}{m_2}) v_1$, which for brevity I write $(1 + K) v_1$. It is clear that K is a positive quantity and that it is greater than unity unless the brighter star is really the smaller of the pair.

If $W' - W''$ represent the observed velocities of the brighter star in the line of sight at two different dates, then

$$W' - W'' = v_1' - v_1'' = \frac{V' - V''}{1 + K}$$

or

$$(1 + K)(W' - W'') = V' - V''$$

and hence

$$\pi\,(1 + K)(W' - W'') = \pi\,(V' - V'')$$

But

$$\pi\,(V' - V'') = B \left\{\cos\,(\theta' - \lambda) - \cos\,(\theta'' - \lambda)\right\}$$

and finally

$$\pi\,(1 + K) = B \left\{ \frac{\cos\,(\theta' - \lambda) - \cos\,(\theta'' - \lambda)}{W' - W''} \right\} \qquad (1)$$

This equation enables us to determine the parallax if the ratio of the masses is known and the ratio of the masses if the parallax is known. But we can determine more than this. B being a constant, so far as the system is concerned, $\cos\,(\theta' - \lambda) - \cos\,(\theta'' - \lambda)$ is greatest when $W' - W''$ is greatest. But the values which make the former expression greatest are evidently $\theta = \lambda$ and $\theta = 180 + \lambda$, when its value is 2. Hence the greatest and least values of W must coincide with these values of θ or with the positions at which the star is at the node of its orbit. This affords a check on any computed orbit; and I may add that the period of the binary star can also be ascertained by the spectroscope since it will be the time which elapses beeween two maxima and two minima values of W, or indeed between any two equal values of W unless W is increasing at one period and diminishing at the other.

We can easily obtain a superior limit to the parallax of a binary star from the foregoing equations. Cos $(\theta' - \lambda) - \cos(\theta'' - \lambda)$ cannot be greater than 2, while $1 + K$ is greater than 2 unless the fainter star is really the larger. Hence π is always less than $\frac{B}{W' - W''}$. When our observations have progressed far enough we can give $W' - W''$ its maximum value in this expression. Until then we can compute the value of $\cos(\theta' - \lambda) - \cos(\theta'' - \lambda)$ for the dates of the observations which give the maximum difference hitherto observed, and if C be this value, the parallax is less than $\frac{\frac{1}{2}CB}{W' - W'}$.

The following appears to be the simplest mode of determining the proper motion of the star in the line of sight. Calling this proper motion x we have

$$W - x = v_1.$$

Hence

$$\frac{W' - x}{W'' - x} = \frac{v_1'}{v_1''} = \frac{V'}{V''} = \frac{\pi V'}{\pi V''}$$

$$\frac{W' - x}{W'' - x} = \frac{A + B\cos(\theta' - \lambda)}{A + B\cos(\theta'' - \lambda)}$$

Observing that $A = B\, e \cos\lambda$, this becomes

$$\frac{W' - x}{W'' - x} = \frac{e\cos\lambda + \cos(\theta' - \lambda)}{e\cos\lambda + \cos(\theta'' - \lambda)} \tag{2}$$

Whence the value of x can be computed.

I have supposed throughout that the star is disturbed by one satellite only. If there was a second satellite the motion of the principal star would be affected by it also, and the existence of an unknown satellite might be discovered by the impossibility of reconciling the spectroscopic measures of velocity with any computed orbit. This must be the case with Sirius if the Greenwich measures of spectroscopic velocity are even approximately correct. These observations were necessarily made in the winter, and I give the means for each winter hitherto published with the number of observations made, + indicating recession, and — approach.

Year.	Velocity in Miles per Second.	No. of. Observations.	
1875—6	+ 20.5	3	
1876—7	(+ 9.3)	1	Average of 3 years, 7 obs. + 20.6
1877—8	+ 25.2	3	
1878—9		0	
1879—80	+ 14.5	4	
1880—1	+ 7.8	4	
1881—2	− 4.2	6	
1882—3	− 3.8	4	
1883—4	− 19.7	13	
1884—5	− 21.5	6	Average of 3 years, 25 obs. −20.3
1885—6	− 20.6	6	
1886—7	− 8.2	5	
1887—8	(− 0.6)	2	(Observations very discordant.)
1888—9	− 21.8	7	

These observations indicate that the maximum value of $W' - W''$ is over 40 miles per second, while the value of B probably does not exceed 3 (for the latest orbit—Mr. Gore's—it is about 2.67), so that the parallax of Sirius on the principles already laid down would be less than $\frac{3}{40}$ of a second. From direct measurements it seems probable that the parallax of the star is five times as great as this, and moreover the dates of the maximum and minimum values of W' (hitherto observed) do not correspond with the nodes of any recognized orbit. The glare of the great star would render it difficult to detect a close satellite, and if the inner satellite passed one node about the year 1877, and the other about 1885, it must be a close one. Further spectroscopic observations on Sirius are much to be desired, and will probably solve the mystery which surrounds its motions at present.

The great value of spectroscopic measurements in the case of binary stars arises from the fact that they can be made when the pair are so close that the distance and position angle can only be measured with great difficulty, if at all. In such cases the value of

$$\frac{\cos(\theta' - \lambda) - \cos(\theta'' - \lambda)}{W' - W''}$$

should still remain constant if the orbit is correct, and the value of θ'' can be computed from the elements of the orbit, while W″ is directly observed. There are a good many instances in which the companion star is in this condition during a portion of its revolution, and here the spectroscope alone can tell us whether it is still where it has been com-

puted to be, or has wandered from the track. The companion of Sirius seems hardly capable of being observed at present. Hence the utility of the spectroscope in that instance if applicable; but for the reason already mentioned I doubt whether it will give any decisive result.

Another point which the spectroscope can clear up is which of the two planes equally inclined to the line of sight is the true plane of the orbit. The value of W will be increasing if the companion is moving in one of these planes at the time when it will be diminishing if the other plane is the true one. Two or three observations of W by the photographic method will probably suffice to determine whether it is increasing or diminishing at any given time, and hence to determine the orbit-plane.

PTOLEMY'S ARGUMENT AGAINST ROTATION OF THE EARTH.

HARRIS HANCOCK.*

For The Messenger.

Professor Newcomb having had occasion in his lectures on the History of Astronomy to bring up the fact that the idea of the rotation of the earth was not foreign to the ancients, at his suggestion I undertook a translation and comparison of those passages of the Greek and Latin editions of the Almagest, which bear on this point. It seems that this idea had gained sufficient weight to require, in Ptolemy's estimation, a repudiation from himself, and he wrote the following passages with that intent:

Almagest, pp. 19 and following.

Now certain persons, since they think that nothing can be said in opposition to these views (*i. e.*, that the earth rotates), agree to them and think that nothing will disprove them, if for the sake of argument they make the hypothesis that the heavens are without motion, but that the earth turns about its axis from the west to the east, making very nearly one turn in each day; or, if both of them move, then it is about one and the same axis, as we said, and in a way conformable to their mutual relations. But it has escaped their notice, so far as concerns the phenomenon of the stars,

*Student at Johns Hopkins University.

that nothing, probably, is opposed to the above mentioned statement, yet this idea appears most absurd in the light of what occurs around about us and in the air. For let us grant with them—what to be sure is contrary to nature—that the things, which are lightest and composed of the most subtle (opposed to compact, which follows) parts either don't move at all, or with exactly the same motion as those of opposite nature.

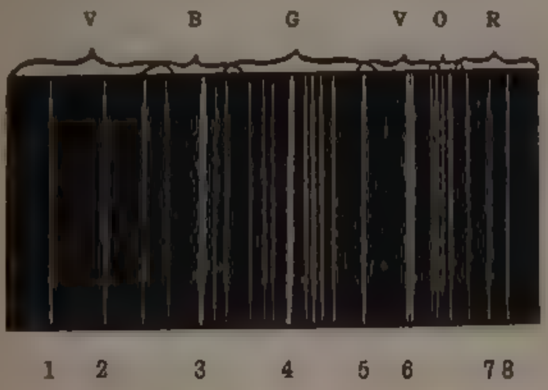
Then they must account for the fact that things in the air, even tho' they be composed of heavier particles, yet, evidently move more swiftly than all those bodies, which are more terrestrial. Again let us grant, that the things which are heaviest, and which are composed of the most compact parts, have a peculiar motion of their own very rapid and constant. Then they must account for the fact, that the terrestrial things sometimes do not readily yield to impulse imported from without. In view of these facts they will be obliged to acknowledge that the revolution of the earth is far more rapid than the revolutions of all things that are around it; otherwise it could not make such a great revolution in such a short while. Now if this is the case, all the bodies which are not affixed to it would always appear to be revolving in an opposite way to the earth, and neither a cloud, nor a bird, nor anything thrown would appear to go to the east. For the earth would always get ahead of and anticipate their motion towards the east. Thus all the other bodies, with the exception, of course, of the earth, would appear to fall back towards the west. Now if they should say that the air is carried about by the earth in its revolution at the same rate of speed as itself, it is true that the bodies contained in the air would not have the same rapid rate of speed; or, if they should be carried about, as if they were one and the same body with the air, they would appear to have neither greater nor less speed than the atmosphere, and would seem stationary; furthermore, if they should be flying, or if they should be thrown, they would not appear to make any motion of any kind. This is just what we see brought to pass, as though no retardation or acceleration were imparted to them by the fact that the earth does not stand still.

LIGHTNING SPECTRA.

For The Messenger

To those readers of THE MESSENGER who are interested in spectroscopic work, I respectfully submit the following preliminary studies of the spectrum of lightning. I hope, however, that they will bear in mind that the results thus far obtained, are far from being reliable, because of two obstacles—the instantaneous character of the phenomena, and the insufficiency of my instrumental means. The first cannot be remedied, the second is only a question of instrumental character.

The results I offer (and with some degree of hesitation), were obtained with the Browning direct vision spectroscope, without scale of measurement, and was of small dispersion. The bright lines set forth in the diagram, are mere eye estimates, and are, therefore, very unreliable from a scientific point of view.



BRIGHT LINE SPECTRA OF LIGHTNING.
JUNE 22 1890.

The diagram shows 25 bright lines, and were the results of one evening's observation—previous observations being rejected because of the unfamiliarity with the use of the Browning in the study of lightning spectra, and for the further reason that the display of lightning on the evening referred to was the most brilliant and varied I have ever witnessed. I therefore rejected all previous notes, as being mere training lessons.

It will be found, that two moderately bright lines lie in

the violet, one heavy bright line in the blue, and which I estimate to be the familiar F line, one brilliant line in the green (the coronial or auroral line?); one brilliant line on the yellowish green, a double line in the yellow—very brilliant (the sodium line?), a fainter but fairly broad line on the edge of the red, and two very bright lines in the center of the red, one of which I think is a hydrogen line—possibly both The fainter bright lines lie approximately as shown in diagram. The intense flashes, those which usually do the damage during a storm, gave *exceptionally* faint continous spectra, and rarely more, than the lines number 3, 4 and 5 Heat lightning flashes gave the principal bright lines 1 to 8, and the spaces between were occupied by a multitude of finer bright lines. The absorption band in the violet, mentioned in my previous note to THE MESSENGER, occurred in all *bright* flashes of heat lightning and in some cases I saw two such bands in the red, lying on either side of the pair 7 and 8

I will leave the determination of the records to some one interested, who can place the lines in their *approximate* position in wave length.

It might be well to state that the line, which I judge to be the auroral line, was in all cases the most noticeable, and especially so in discharges of heat electricity which seemed to occur in the upper and more rarified strata of the air.

A spectroscope containing an illuminated scale would, I think, be the proper and more correct method of viewing lightning spectra, and I hope persons possessing such may find time for this sort of investigation.

MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC.

The Society met at Mt. Hamilton May 31, 1890, with a good attendance. After transacting the routine business the following papers were presented:

a. The eclipse of Dec. 21, 1889, by Edward S. Holden.

b. The Astronomical Society of Camden, New Jersey, by A. B. Depuy, secretary.

c. Elements of Comet Brooks (March 19) by A. O. Leuschner.

d. On the Criterion of Continuity of Functions of a Real Variable and on the Theorem of Mean Value, by Professor I. Stringham.

e. Does the Color of a Star Indicate Its Age? by William M. Pearson.

f. Remarks on the Mechanical Theory of the Corona, previously proposed, by Professor J. M. Schaeberle.

g. Note on the Definition, the Resolving Power, and the Accuracy of Microscopes and Telescopes, by Professor A. A. Michaelson.

Owing to a lack of time only *e* and *f* were read.

Mr. Pierson after presenting a table of the colors and of the magnitudes of stars known to be binary, and therefore presumably composed of the same elements, and after pointing out that binaries of the same magnitude were of the same colors, while those of different magnitudes were of different colors said:

"In all these binary systems, if the stars are of the same size, they are invariably of the same color; if, on the other hand, the magnitudes differ, the colors of the components differ in an approximately exact ratio, and where one of the members is smaller than the other, its color is invariably nearer the blue end of the spectrum than that of the larger. Thus if the larger is red, the smaller may be yellow or white; if the larger is yellowish or white, the smaller is green, or lilac, or blue; while no binary has ever been discovered where the larger star is blue or white, and its smaller companion yellow or red; or where the smaller was nearer the red end of the spectrum than its primary.

Assuming then that two stars have the same nebulous origin, are exposed to the same conditions in space, that the smaller of the two is invariably of a hue farther removed from the red end of the spectrum than the larger, the question arises —which is the older? *i. e.*, which the more developed from the original nebulous condition,—the larger or more nearly red, or the smaller or more nearly blue?

If the bluer star be the hotter, and, therefore, the newer, or more recently emerged from its nebulous origin, then the smaller of the two bodies composed of the same elements and having a common origin, must be the hotter, which is not likely. . . . If, then, we are to apply to these binary

systems the laws of heat and of the cooling of masses; if we are to be guided by the analogies of our own solar system, and if it be not unreasonable to assume that the same laws operate in other systems, it would seem to follow that the smaller of two components of a binary star cannot be of a higher temperature than the larger, and, therefore, must be older in development from the nebulous stage. If this be so, then observation of the binary stars proves that the cooler the star the more its color tends toward the blue end of the spectrum. It would further seem to be a fair deduction from that conclusion that the tendency toward the blue in the color of any star, binary or independent, would indicate that the star is cooler and older, relatively, than the star whose hue tends towards the red or yellow."

In the discussion which followed Mr. Pierson adduced the cases of Algol and of Nova Cygni, etc., as giving further support to his thesis.

Professor Schaeberle spoke of certain objections which had been raised against his mechanical theory of the Solar Corona, and showed that they were all completely met by this theory. So far as he knew there was no phenomenon of the corona which was not completely and satisfactorily explained by the hypothesis which he had proposed. The forthcoming eclipse report would contain what seemed to be a satisfactory demonstration of all points involved.

Thirty-three new members were elected as below:

Messrs. Babson (Cal.), Bailey (Miss.), Cameron (Nova Scotia), Chapin (Conn.), Charropin (Mo.), Chubbock (Mass.), Mrs. Thornburg-Cropper (Cal.), Messrs. Dyer (Cal.), Everett (Cal.); Mrs. Fillmore (Cal.), Dr. David Gill, F. R. S. (Cape of Good Hope), Messrs. Hemming (Minn.), Hirst (Cal.), Hooper (Maryland), Irish (Nevada), Köhl (Denmark), Loomis (Washington), Michaelson (Mass.), Miller (Cal.), Mrs. and Miss Morrill (Cal.), Messrs. Moorman (Ia.), Nickerson (Cal.), Poor (Md.), Pritchett (Mo.), Sawyer (Cal.), Schott y Larios (Spain), Searle (D. C.), Smith (Me.), Talbot (Cal.), Tobin (Cal.), Warner (O.), Winlock (D. C.) CHARLES BURCKHALTER, Secretary.

Notes on Some of the Double Stars Discovered at Washburn Observatory.

S. W. BURNHAM.

In the February number of THE SIDEREAL MESSENGER, Professor Comstock has called attention to apparent changes in the angles and distances of some of the double stars discovered by me in 1881 at the Washburn Observatory. That all measures of double stars, like other astronomical observations, are more or less erroneous requires no demonstration, but it is very doubtful if any doctoring, systematic or other wise, can improve the results. This can only come from continued and painstaking practice with the micrometer.

In the last month or two, I have re-measured a few of these pairs, principally with the 36-inch telescope, from which I make the following notes:

The change in β 815 is due to proper motion, which amounts to about 0″.15 annually in the direction of something like 145°, assuming the motion to belong to the larger component. I measured this pair in 1889, and again during the present year.

In the case of β 794 there appears to be considerable change in the angle, the distance remaining substantially the same. By measures on four nights with the 36-inch, I get

$$P = 126°.9 \qquad D = 0''.50 \qquad 1890.35$$

This is smaller than the Madison measure in 1889, but 20° larger than that found by me in 1881. The large telescope shows two other faint companions not before seen:

$A\ B$ and C	$P = 71°.8$	$D = 5''.71$	1890.37	2n
$A\ B$ and D	78 .6	26 .73	1890.37	2n

I have made a set of measures of β 800. These do not agree very well in angle with the later Madison measures, and do not explain the apparent discrepancy in distance when compared with my first measures at the Washburn Observatory, assuming there is no error in the printed results. The pair is a very easy one, even with the 12-inch, and the measures should be fairly accordant if the components are fixed.

I have had no opportunity yet to re-measure the other pairs cited, but hope to do so hereafter. In stars of this class decided change would be expected in many of them, and I am glad to know that the Madison telescope is being used in their re-measurement.

Mt. Hamilton, June 3.

The System of Zeta Cancri

MISS AGNES M. CLERKE.

No feature of recent astronomical progress is more curious than the variety of ways in which the multiplicity of stellar combinations has been brought to light. By the analyzing power of great refractors, especially as used by Mr. Burnham, so many stars already divided have been still further broken up; so many apparently binary unions have been resolved into associations of partial systems, as to suggest that the process ceases only through the merging effects of distance from ourselves on the one hand, and of the mutual proximity of the conjoined suns on the other. Spectroscopic revelations—"epoch-making" in character—of exceedingly close bright satellites to bright stars, circulating with great rapidity in periods of a few days, confirm this suspicion. Without undervaluing the prospects of future optical improvement, it may be asserted that few or none of these can ever be rendered accessible to direct scrutiny. At their greatest elongations, the gap of space between them and their primaries makes, from our point of view, too thin a line for possible discernment.

But the telescope may be baffled by lack of light, as well as by lack of room for observation. For aught it can tell non-luminous "stars" may, according to the conjecture of Laplace, strew the sidereal tracts as plentifully as luminous ones. The modern armory, however, is stocked with multiform weapons of research. Partial eclipses of bright by opaque masses, alleged by Goodriche over a century ago, in explanation of the variability of Algol, have been "spectrographically" demonstrated to occur; and the periodical changes of radical velocity, detected by Professor Vogel, in April, 1890, in α Virginis, and suspected in Rigel, show that these stars also belong virtually to the Algol class, althoug

our situation is too far removed from their orbital planes to permit the visibility of occultations.

The gravitational influence of unseen masses may also become sensible through disturbance of tangential movement, whether of the translatory, or of the circulatory kind, but under conditions opposite to those favoring "line-of-sight" determinations. That is to say, the orbit of the disturbing body must be both spacious and highly inclined to the visual ray. Thus, the sinuosities of the track pursued across the sphere by Procyon would be imperceptible if greatly foreshortened; and the circumstance that the revolutions of ζ Cancri are executed (as it would seem) in a plane differing little from the plane of projection, has alone rendered possible the discovery that a syetem visually triple is physically quadruple.

The more distant companion at 5".5 was first noted by Tobias Mayer, in 1756, and Father Christian Mayer's observation of it at Mannheim, in 1778, already sufficed to show its retrograde motion. Herschel re-divided the larger star in 1781, and, from 1826 onwards, the trio were kept under pretty constant supervision. They proved, for a ternary combination, unusually mobile, the close couple *A B* mutually revolving in sixty years, their attendant *C* circling round their optical centre at the average rate of half a degree annally, but, with singular alternations of delay and acceleration, emphasized, too, by the peculiarity of an approach to the centre at each epoch of arrested or inverted angular change, while retreat from it marked the intervals of swifter revolution. Dr. Otto Struve's explanation* of these anomalies by the influence of an obscure mass in the immediate vicinity of the star *C*, has been fully confirmed by the researches of Professor Seeliger, in 1880 and 1889.† The looped path pursued by *C* results, there can be no reasonable doubt, from its circulation round an invisible close companion in a period of about eighteen years, at the same time that it describes a much wider ellipse round the pair *A B*. Since 1826, it has completed three subordinate revolutions, in an orbit of slight eccentricity, the semi-major axis of which subtends an angle of two-tenths of a second.

* *Comptes Rendus*, t. lxxix, p. 1463.

† *Sitzungsberichte*, Wien, Bd. lxxxiii, Abth. 2, p. 1018; *Denkschriften*, Munich, Bd. xvii, Abth. 1.

The dark star *D*, meanwhile, revolves in the same period round the same centre, and at a distance from it, as Professor Seeliger has shown, little if at all, greater than that of *C*. It cannot, then be much inferior, and may be greatly superior to it in mass. Yet it does not emit light enough to be discerned, even by Mr. Burnham, with the aid of the great Lick refractor. This example alone—and several others might be alleged—proves, with tolerable conclusiveness, that the differences in point of intrinsic brightness between the components of multiple stellar systems does not depend solely upon the swifter cooling of the smaller bodies.

The system of ζ Cancri, as we now know it, consists of four masses, closely associated, two and two together; and it has been demonstrated by Professor Seeliger, that in combinations of this type, Kepler's law of equal areas holds good for the elliptic movement of the centre of gravity of one pair around the centre of gravity of the other. Thus understood, it is obeyed, within the limits of observational error, by the stars in question. Their individual perturbations, however, constitute a problem in celestial dynamics which, in the actual state of science, can receive only an approximate solution. Their gyrations are, nevertheless, for the present, sufficiently will represented by nearly circular tracks lying respectively in planes deviating little from the plane of projection. Should the larger mutual orbit of the circling pairs prove eventually to be similarly-shaped and situated, then the *annus magnus* of the system is about 720 years; and all its movements, traced out before our eyes with insignificant foreshortening, are directed so as to favor to the utmost telescopic, but to preclude spectroscopic, determinations. But the record of observation must be greatly lengthened before the orbit of *C* round *A B* can possibly be computed.

The components of ζ Cancri usually show a yellow color; but Dembowski found them all white, in 1855-57, and noticed, in 1864-65, an obvious change in *C* to yellowish or olive.* Their magnitudes, photometrically measured at Harvard College as respectively 5.6, 6.3, and 6.0, also perhaps fluctuate slightly, but not so as to disturb the *order* of their brightness. The star *A* always outshines

*Astr. Nach-, No. 1574.

both *B* and *C*; while *C*, to a trifling extent, surpasses *B*. The proportion of their masses may, however, differ widely from the proportion of their light. Seeliger finds that the best agreement with observation is obtained by ascribing to *C* a mass 2.37 times the combined masses of *A* and *B*; but until its period and mean distance have been computed, nothing can really be known on the point.

Should the distance of the system from the earth prove measurable, absolute will be substituted for relative values of mass; but the prospect in this direction is not very encouraging. The "hypothetical parallax" of the couple *A B*, on Mädler's principle of assuming the two together to possess the same attractive power with our sun, is about five-hundredths of a second, corresponding to a light journey of nearly sixty years; and since they are likely to be more massive, they are also likely to be more remote. Mass varies in the triplicate ratio of distance; an eight-fold mass implies a double distance, and so on. A small if not wholly evanescent parallax is also indicated by the secular proper motion of 15′.2, common to the three stars. They appear to be of great intrinsic brilliancy. If of the solar mean density, the stars *A B* must shine with nine times the solar lustre. This is, indeed, only what we should expect from the quality of their light; but it is a matter for surprise that all the stars yet known to be attended by obscure satellites show Sirian spectra, and stand accordingly themselves at the very summit of luminous intensity.—*From Publications No. 9 Astronomical Society of the Pacific.*

ON A RE-DETERMINATION OF THE PRINCIPAL LINE IN THE SPECTRUM OF THE NEBULA IN ORION, AND ON THE CHARACTER OF THE LINE.

WILLIAM HUGGINS, D. C. L., LL. D., F. R. S., AND MRS. HUGGINS.

We think it desirable to put on record the results of a re-determination of the position of the principal line in the spectrum of the nebula of Orion, under the more favorable conditions of a higher position of the nebula, and of some improvements in the instrumental arangementss. The spectroscopes have been furnished with new and sensibly perfect object-glasses by Sir Howard Grubb, and a new bright

pointer has been fitted to the spectroscopes by Mr Hilger, which is illuminated by a small incandescent lamp, of which the brightness is controlled by uitable sresistances. In all other respects the instrumental arrangements have remained unaltered. The same spectroscope, giving a dispersion of about four prisms, which was described in my paper of 1872 as spectroscope B,* and was used in the work on this line contained in my paper of 1874,† and also throughout the work of last year, with the exception of one single confirmatory observation with amore powerful spectroscope,‡ was employed in the present investigation, and also the same arrangements for the comparison spectrum from burning magnesium.

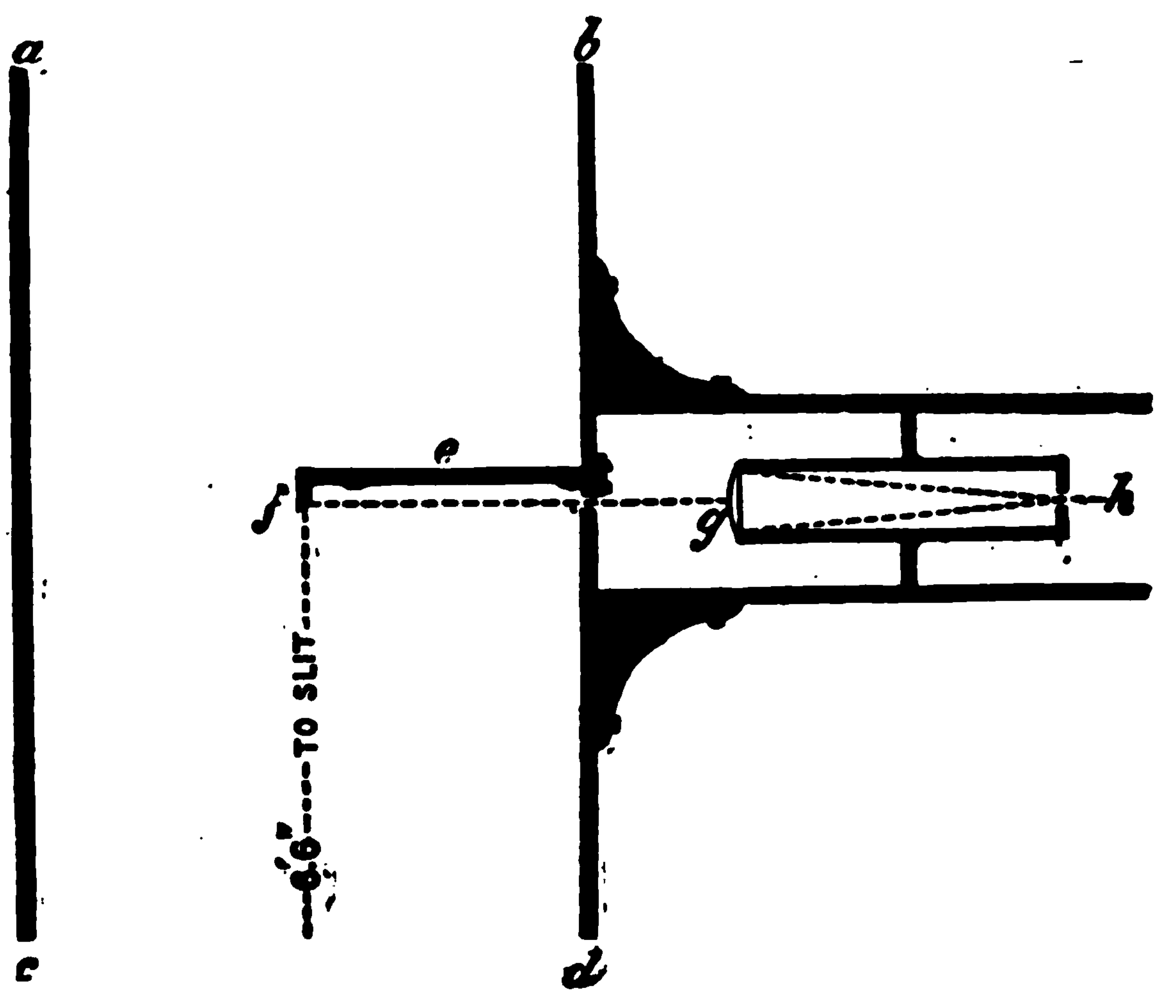
In my earlier spectroscopic work I pointed out that a possible parallactic error of the comparison spectrum may easily come in when a small reflecting prism is placed in the usual way before one-half of the slit; and also the possibility of errors from the unavoidable flexure of the spectroscope or of its attachments to the telescope. In 1872 I adopted the plan of placing "the spark or vacuum tube within the telescope at a moderate distance from the slit For this purpose holes were drilled in the telescope tube opposite to each other, at a distance of 2 feet 6 inches within the principal focus. Tubes were fixed by screws over these holes, and in these tubes slide suitable holders for carrying electrodes or vacuum tubes. The final adjustment was tested by the comparison of the bright lines of magnesium and the double line of sodium with the Frauenhofer lines *b.* and D in the spectrum of the moon."§

I have since adopted an arrangement in which, when once adjusted, any sensible parallactic effect from a change of position of the source of light seems to be impossible, for even a minute motion of the spark or other source of light for comparison has the effect of throwing the light to one side, without the slit; so that, as long as the comparison spectrum is seen, there can be no doubt that the direction of the light for comparison, as it fell upon the slit, had remained invariably the same, relatively to the optical axis of

* 'Roy Soc Proc,' vol 20, 1872, p 382
† 'Roy Soc Proc,' vol 22, 1874, p 252
‡ 'Roy Soc. Proc.,' vol. 46, 1889 pp. 50, 51
§ 'Roy Soc Proc,' vol 20, p 382

the telescope, and consequently to the celestial spectrum under observation.

In the diagram, *abcd* represents a section of the telescope-tube near the middle of its length; within this is firmly screwed a thin steel arm, *e*, carrying a minute mirror, *f*. This mirror is about a quarter of an inch in width, and of about the same apparent length, when seen fore-shortened from the slit. The mirror is fixed at a distance of 6 feet 6 inches within the principal focus where the slit is placed. In the side of the tube opposite the face of the mirror is a small hole, through which the light from the collimator, *g*, passes



on to the mirror. At the other end of the collimator, which has a length of about 7 inches, is a diaphragm with a small hole, *h*, before which the source of light, whether an induction spark, a vacuum-tube, or burning magnesium is placed. The lens at *g* is so placed as to bring the light approximately to focus at the place of the slit.

It is obvious that with this arrangement an extremely small shift of the light before the hole, *h*, would be sufficient to cause the ray reflected from the mirror to go off the slit, and that the reflected light can pass into the slit only so long as its direction remains invariable relative to the optical axis of the telescope. It is also obvious that any flexure

in the spectroscope, or in the tube connecting it to the telescope, would affect similarly the light from the nebula and from the magnesium. The precaution was taken, however, to so orient the spectroscope, that any flexure from the weight of the instrument would be in the direction of the length of the slit.

The coincidence or otherwise of the direction of the light reflected from the little mirror with the optical axis of the telescope can be determined by comparing the spectrum of burning magnesium with *b* in the spectrum of the moon, or of the light of the sky. As an additional safeguard in the comparison of the spectrum of the nebula with magnesium, since my early observations had shown the nebular line to be very slightly more refrangible, the mirror was purposely so adjusted, that, though the lines of the burning magnesium were seen to fall upon the corresponding dark lines *b* in the moon or sky, yet a careful observation would show a very minute overlapping of the bright lines toward the blue. This state of things would diminish a little the interval which should be seen between the nebular line and the termination of the magnesium-flame band, and so make the observation more difficult. It is evident that if under such circumstances of adjustment the nebular line were seen on the more refrangible side of the magnesia band, the observation, being a delicate one, would be more trustworthy, for in the case of coincidence with magnesium the line would appear towards the opposite and less refrangibleside of the magnesia line, broadening the line towards the red (*loc. sit.* p. 49).

The stability of this adjustment depends upon the rigidity of position of the little mirror within the telescope; as this weighs only the small fraction of an ounce, and is supported by a strong steel arm firmly attached by four screws to the steel tube of the telescope, there is an almost complete absence of any chance of its displacement. During twelve months not the smallest alteration has been detected, though very careful examinations have been frequently made.

At the time the comparisons were made last year, namely, in March, the nebula was getting low, and from perhaps an excess of caution I described them as follows: "Although I

consider the results to be satisfactory, I prefer to say that I and Mrs. Huggins, independently, believed fully at the time that we saw the appearance which all former observations of the line led me to expect, namely, the nebular line to fall within the termination of the magnesium band" (*loc. cit.* p. 49.)

This year the position of the nebular line within the termination of the magnesia band has been confirmed by both of us independently on several nights.

The more refrangible position of the nebular line relatively to the termination line of the MgO band has been ascertained not only by repeated comparisons of the two spectra by means of a suitably illuminated pointer, but also this year, as last year, by occasional moments of direct vision of the nebular line upon and within the magnesia band. It is only occasionally that the necessary relative brightness of the band can be secured, but such moments of direct vision of the two spectra are very trustworthy.

On February 9th Professor Liveing made some observations on the spectrum of the nebula, and I have his permission to quote from the notes which he entered at the time in my observatory book. During the afternoon he examined the adjustments of the little mirror. His words are: "Observed in Dr. Huggins' spectroscope attached to his telescope the Fraunhofer lines *b*, as given by the clouds, and the bright lines of burning magnesium thrown in by reflection. The solar spectrum was but faint, so that it was necessary to use rather a wide slit. I observed a close coincidence between the dark lines of the sky light and the bright lines of the burning magnesium; the two overlapped, but the dark lines extended a very little on the less refrangible side, the brightest line a little on the more refrangible side beyond the dark line."

In the evening he observed the nebula, and recorded his observations in the following words: "Observed the spectrum of the nebula in Orion, and compared the position of the least refrangible line with the magnesia fluting. The latter was thrown in by reflection from burning magnesium. I put the nebular line on the pointer first, and then from time to time the magnesium was burnt. I made quite sure that the edge of the magnesia fluting was less refrangible

than the nebular line; repeated the observations several times. Tried to see both the nebular line and the fluting at the same time, but found it hard to see both at once, but I still came to the same conclusion, namely, that the edge of the fluting was less refrangible than the nebular line."

Afterwards Professor Liveing observed the third line of the nebula, together with Hβ from a vacuum-tube. He says: "Compared the position of the most refrangible of the nebular lines with the F line of hydrogen thrown in by reflection from a vacuum-tube, the coincidence seemed perfect, as the one line fell upon the other."

We have since gone further, and attempted a quantitative estimation of the distance of the nebular line within the termination of the band. For this purpose we made use of the minute apparent breadth of the illuminated pointer tip as a measuring unit. The value of this unit was determined by measuring with it the distance of b_1 from b_4 in the solar spectrum.

Independent estimations made by both of us on several occasions agreed in assigning to this distance, after taking into account the minute displacement of the comparison-spectrum by the little mirror towards the blue,

A wave-length of about............. λ 0001.5.

Deducting this distance from λ 5006.5, the position of the termination of the band, we get for the nebular line

A position of about........................λ 5005.0.

At the time of these observations the earth's motion caused the nebular line to be degraded toward the red by about λ 0000.25. If, therefore, the great nebula has no motion of its own, this interval must be deducted from the observed position of the nebular line,

Placing it at about........................λ 5004.75.

The observations recorded in the paper of 1874* gave the position of the nebular line relatively to the fiducial lead line with an accuracy not less than λ 0000.5. This relative posi-

* Roy. Soc. Proc., vol. 22, 1874. This paper claims for the determination of the position of this line in the case of seven nebulæ an accuracy sufficiently great to show a motion of twenty-five miles per second. This motion corresponds to about λ 0000.67, but as some of the nebulæ were more difficult to observe than the bright nebula in Orion, the accuracy of the determination of the line in this nebula may certainly be taken as not less than the amount given in the text, namely, λ 0000.5.

tion was translated into wave-lengths in our paper on the Nebula (*loc. cit.*, p. 45), showing that the nebular line lies from about λ 5004.6 to about 5004.8.

The question whether this nebula has a motion in the line of sight must be determined by comparisons of the third line with the corresponding bright line of a hydrogen vacuum-tube. The observations I recorded in 1874, as well as those of Mr. Maunder, of Greenwich (*loc. cit.*), "show that the nebula has very little, if any, sensible motion in the line of sight."

The direct comparison was made on several nights with results similar to the observation that Professor Liveing recorded on February 9, namely, that "the coincidence seemed perfect as the one line fell upon the other."

We have endeavored to push this observation further, to determine if the coincidence was absolute, or whether there was a very minute overlapping of the edges of the two lines. The adjustment of the apparatus would throw the hydrogen line, to a very minute extent, towards the blue, at the same time that the earth's motion would degrade the nebular line from the hydrogen line towards the red.

The faintness of the third line with a narrow slit does not permit us to speak with absolute certainty as to the extent which the hydrogen seemed to overlap the nebular line towards the blue.

We were quite certain that the hydrogen line did overlap the nebular slightly towards the blue, but we were unable to determine whether the overlapping corresponded accurately to the earth's motion at the time of observation. It appeared to do so approximately, which would support my former conclusion, that the "nebula has very little, if any, sensible motion in the line of sight."

PART II.

On the Character of the Principal Line in the Spectrum of the Nebula in Orion.

In our paper last year (*loc. cit.*, p. 53) I stated that "my own observations of this line, since my discovery of it in 1864 . . . show the line to become narrow as the slit is made narrow, and to be sharply and perfectly defined at both

edges." We gave also the corroborative evidence of two accurate observers who have made a special study of the spectrum of gaseous nebulæ, Professor Vogel and Dr. Copeland.

Since last year the defining power of the spectroscopes has been improved by two new object glasses by Sir Howard Grubb. The nebular line has been subjected on several nights to a very searching examination with different widths of slit; and with different magnifying powers on two spectroscopes—the one with a single prism of 60°, the other the "four-prism" spectroscope (*loc. cit.*, p. 49).

We came to the conclusion that a marked feature of this line is its sharply defined character on the more refrangible side, we were unable under any of the conditions of observing to detect even a suspicion of any softening of the more refrangible edge of the line; much less the faintest indication of a "flare," and certainly not the distinctive peculiarity of a "fluting."

In the case of observations with small dispersion, the eye is helped by placing the second line, which then appears near the first, behind a bar fixed in the eye-piece.

Observations of the nebula in Orion by eye, as well as the photographs of Mr. Common and of Mr. Roberts, show numerous small irregularities in the brightness of the nebula, which give rise to a closely-mottled appearance. As the length of the slit takes in a considerable angular extent of nebula, several of these irregularities of brightness or "mottlings" are usually included within it, giving to the nebular lines an irregularly bright or blotchy appearance. As the nebula is allowed to pass over the slit this blotchy appearance is seen to vary in the size and in the number of the brighter patches, and also in their brightness relatively to the less luminous spaces between them. At the first glance, in some positions of the slit upon the nebula, the lines, and especially the principal line as the brightest, appear serrated at the edges. A little attention soon shows that this is a purely physiological effect due to the greater brightness of the patches, and that the brighter parts of the line do not really project beyond the less brilliant intervals between them. One marked character of this phenomenon is that both edges of the lines appear equally serrated, and that there is no indication of a spreading of the brighter patches

towards the blue only. It is easily ascertained that this more or less patchy condition is not peculiar to the principal line, for precisely the same patches can be detected in the other two lines, which can be seen to correspond in number and in position within the lines.

These observations, repeated on several nights, have left no doubt in our minds that the principal line is certainly as sharp and as bright on the side towards the blue as on the less refrangible side.

On February 9, Professor Liveing scrutinized the character of this line. His words are: "Observed the nebular line with various widths of slit. The line always appeared sharply defined on the more refrangible side, whether the slit were wide or narrow. On gradually closing the slit, the line fined down to a very fine line. The same appearance as to sharpness on the more refrangible side was observable with a spectroscope of less dispersive power and with eye-pieces of low power as with the higher dispersion and greater magnification."

The observations recorded in this paper appear to us to show conclusively:

(1.) That the principal line is not coincident with, but falls within, the termination of the magnesium-flame band.

(2.) That in the nebula of Orion this line presents no appearance of being a "fluting."

It is scarcely needful to say that, in the face of the observations recorded in this paper, we are not able to accept the conclusions of Professor Lockyer's recent papers, namely: "On the Chief Line in the Spectrum of the Nebulæ," "Note on the Spectrum of Orion," and "Preliminary Note on Photographs of the Spectrum of the Nebula in Orion." We observe that Professor Lockyer confirms my statement made in 1874,* that the second line "is sensibly coincident with an iron wave-length 4957" (Thalén, λ 4956.8; Liveing and Dewar, λ 4956.9); and also that Professor Lockyer's photographs confirm my photographs of 1882, 1888, and 1889, in that it is a single strong line, and not a triplet, which appears in the ultra-violet region, and that this strong line is more refrangible than the first component of the magnesic oxide triplet.†

* 'Roy. Soc. Proc.,' vol. 22, p. 252.
† 'Roy. Soc. Proc.,' vol. 46, p. 54.

1. *Addendum on the Position of the Line.*

One of the planetary nebulæ, in the spectra of which I found in my earlier comparisons with lead* in 1874, that the principal line had sensibly the same position as the corresponding line in the nebula of Orion was Σ. 5 (G. C. 4234). We have now compared again the principal line in this nebula with the lead line λ 5004.5 with the same spectroscope (spectroscope B, 3 eye-piece) and an arrangement for the comparison spectrum similar to that described in the first part of this paper, but in which the small mirror has been replaced by a very small total reflecting prism. The correctness of position of the comparison spectrum was ascertained by repeated comparisons of the bright lines of magnesium at *b* with the corresponding dark lines in the sun's light reflected from the sky.

When in this spectroscope the spectrum of lead is observed together with that of burning magnesium, the lead line is seen to fall within, and to be separated by a clear space from, the terminal line of the magnesium-flame fluting.

The principal line of Σ. 5, like that of the nebula of Orion, appears when the slit is made narrow to be very thin and clearly defined at both edges. The lead line is a thin and defined line; if, therefore, the nebular line were coincident with the terminal line of the magnesium-flame fluting, it would appear in the spectroscope to be separated by a clear space from the lead line towards the red. As the angular diameter of the nebula is small, the line is much shorter than the lead line—not longer than about one-third of the height of the spectrum, and consequently its position relatively to the lead line, even when it falls partly upon it, can be very accurately determined.

The nebular line was seen as a short thin bright line, partly upon, and partly clinging to, the lead line. The nebular in our instrument certainly fell upon the lead line, but overlapped it a very little, though not so much as by half its breadth, on the less refrangible side. This position agrees precisely with that described in my early observations made nearly twenty years ago, when I employed for the first time lead as a fiducial comparison line.† As I stated in 1874,‡

* 'Roy. Soc. Rroc.,' vol. 22, 1874, p. 254.
† 'Roy. Soc. Proc.,' vol. 22, p. 252.
‡ *Ibid.*

"If the greater prism power could be brought to bear upon the nebulæ, the line in the lead spectrum would be found to be in a small degree more refrangible than the line in the nebula;" and, of course, if sufficient power of dispersion were employed, the nebular line would be seen separated from the lead line towards the red, and not as in our instrument, partly upon the lead line.

These observations, both those by myself in 1874, and the recent observations made by both of us independently on four different nights, place the nebular line exactly where it was found to be by our direct comparisons with burning magnesium with the nebula of Orion (which were confirmed by Professor Liveing), namely, as not coincident with, but as falling within, the terminal line of the magnesium-flame spectrum.

It should be stated that on two nights we made comparisons of Σ. 5 with burning magnesium, both directly and indirectly by means of the illuminated pointer. The observations completely confirmed the results of the lead comparisons, which were, however, more easily made, as it is difficult to see the exact position of the short nebular line when it is upon the bright fluting.

2. *Addendum on the Character of the Line.*

I am permitted by Dr. Copeland, Professor Young, and Mr. Keeler, of the Lick Observatory, to quote the following observations which they have been so kind as to make at my request, of the character of the principal line in the spectrum of the great nebula in Orion.

Dr. Copeland writes, dated March 26, 1890: "I find it difficult to make anything satisfactory of nebular spectra with my present apparatus, working in the smoke of Edinburgh. . . . On the 14th I saw the three lines as well as I am likely to see them until we get to work at the new Observatory. All the lines were just as broad as the slit; when the slit was wide open they were broad, and when the slit was closed slowly they gradually became narrower and narrower."

Professor Young, writing on March 21, 1890, says: "I have not been able this winter to try the observations for wave-length, having no convenience for the comparison spec-

trum, but I have carefully examined the spectrum of the nebula of Orion, both with a heavy glass prism, and with a grating of 14,000 to the inch, and a collimator of 16 inches focus. With the prism the brightest nebular line seemed absolutely *sharp*, and cleanly defined on both sides; with the grating the line was fainter, and I could not use so narrow a slit, the dispersion was much higher also; the line therefore was a little hazy, *but equally so on both sides*.

At the Lick Observatory there was a continuance of bad weather during the early months of the year, but Mr. Keeler, with Professor Holden's kind permission, observed the nebula on two nights. He observed successively with one prism, a powerful compound prism, and then with a Rowland grating, 14,000 + lines to the inch. With this grating, the collimator was twenty inches in length, the observing telescope 10½ inches, with an eye-piece magnifying 13.3 times. The slit was narrow, 0.0025 inch. The spectra up to the fourth order were employed.

Mr. Keeler says: One thing that struck me particularly, and that there could be no doubt of, was the perfect sharpness and fineness of the nebular lines under the very considerable dispersion used. There is not the least doubt in my mind that they are all of gaseous origin—not 'remnants of flutings."

P. S. June 15. Received a telegram from the Lick Observatory to say that Mr. Keéler has confirmed my position of the principal line of the spectrum of Σ. 5.

NOTE ON THE PHOTOGRAPHIC SPECTRUM OF THE GREAT NEBULA IN ORION.

WILLIAM HUGGINS, D. C. L., LL. D., F. R. S., AND MRS. HUGGINS.

From an examination of the photographs of the spectrum of the uebula in Orion taken by us in 1882, 1888, and 1889, we suggested in our paper "On the Spectrum, Visible and Photographic, of the Great Nebula in Orion,"* "that the mottled and broken-up character of the nebular matter shown in Lord Rosse's drawings from eye-observations, and much more strikingly brought out in the recent photographs

* 'Roy. Soc. Proc.,' vol. 46, p. 42.

of Mr. Common and of Mr. Roberts, may be connected with differences of spectrum in the photographic region, though in the visible region there is no known alteration of the spectrum of the four bright lines, except it may be some small differences of relative brilliancy of the lines. Until next winter we connot go beyond the new information which these photographs give to us."

Unfortunately, the neccessity thrown upon us of making a laborious redetermination of the position and character of the principal line in the visible spectrum, which has confirmed in every point the results contained in our paper of last year (*loc. cit.*), has deprived us of the more favorable opportunities during the past season of carrying out our intention of photographing the spectrum of different parts of the nebula.

We have obtained two photographs only, one taken on March 14th and 15th, and the other on March 17th; but these suggest how much information a spectroscopic examination by photography of the nebula in detail would probably give to us.

These photographs taken of almost the same part of the nebula as the photograph of 1889 showed, to our surprise, the lines of hydrogen at *h* and at H strongly impressed upon the plate, though these lines were carefully searched for in vain in our former photographs; in them no trace of these lines could be detected, but the line near G was strong, and there was present a large number of faint lines of some of which the approximate measures were given in our paper.

The new photographs show not only the lines of hydrogen at *h* and H, but also the first two lines of the ultra-violet series in the white stars which I described in 1879.* Four of these lines had been photographed in the spectrum of hydrogen by Dr. H. W. Vogel, in 1879, and the entire series, with the exception of one, has been since obtained by Cornu in exceptionally pure hydrogen.†

The line α at λ 3887.8 is strong, and the next line β at 3834.5, though much fainter, is certainly present. There is evidence of light-action on the plate at the position of the line γ which we believe to be present; and we suspect, from

* 'Phil. Trans.,' 1880, p. 669.
† 'Journal de Physique,' 2nd ser., vol. 5, Aug., 1886.

traces of photographic action, that one or more of the other lines of the white star series might have come out with a longer exposure.

It is not necessary to point out in the present note the importance of the presence of these more refrangible lines of hydrogen in respect of the view we have to take of the condition of things in the nebula. In this connection it is significant that the hydrogen lines are sensibly stronger and broader as the Trapezium with its stars is approached.

Between the hydrogen lines α and β there is a line stronger even than α, which has a wave-length of about λ 3868.

We do not find any line in the photograph exactly at the place of the solar line K; the position of this line appears to correspond to a gap between two lines on the plate. We suspect the broad line on the less refrangible side of the place of K would probably be resolved by a narrower slit into two or more lines.

The strong line which was first seen in our photograph of the nebula taken in 1882 is certainly stronger than Hγ, and is by far the most powerful line in the photographic region. On account of the wide slit employed in my original photograph, I put the line at about λ 3730; from measures of the line in a photograph taken in 1889, with a narrower slit, we found that its position was more refrangible, and we gave the approximate wave-length "about λ 3724." There was necessarily some difficulty in determining its position exactly on account of the small scale on which, from the faintness of the light of the nebula, it is desirable with the telescope at our disposal to take the photographs, and also because in the nebular spectrum itself we had no fiducial line nearer than Hγ. In the photographs taken this year we have the advantage of the known position of the hydrogen line at H, and with the help of this line our recent measures show that the "about" must be interpreted as slightly less refrangible than λ 3724. Without attempting to fix its position absolutely, we believe that the line will be found to fall between λ 3725 and λ 3726. It is, however, now certain that the line does not coincide with any of the three components of the magnesic oxide triplet, but is less refrangible than the middle line at λ 3724, and falls between this line and the first line of the triplet at λ 3730.

In these photographs there is a strong line, besides many faint lines, on the less refrangible side of G.

The background of the spectrum is seen to contain numerous faint lines, which as far as we have been able to identify them, are the same as those seen in our earlier photographs, of some of which approximate measures were given in our paper, but they are, possibly on account of a slightly wider slit, not so easily measured as they were in the former photographs, in which no trace of the hydrogen lines at *h* and at H could be detected.

A marked feature of the lines is their abruptly different intensities at different parts of their length, giving the blotchy appearance which is characteristic of the lines in the visible spectrum, and which we have described in our recent paper "On a Redetermination of the Position and Character of the Principal Line in the Spectrum of the Nebula in Orion." The length of the slit takes in a large angular extent of the nebula, and, therefore, usually includes within it one or more of the brighter "mottlings" which are so well shown in photographs of the nebula. It is to be remarked that these brighter blotches are sharply bounded, showing that the different parts of the nebula are distinct and become suddenly brighter than the neighboring parts.

The lines of the new photographs contain two very strong and abruptly-bounded blotches, and a third one less marked.

These bright blotches, corresponding to different conditions of closely-adjacent nebular matter, give an explanation of an appearance which we recorded last year in speaking of the strong line "about λ 3724." "On one side of the star-spectra this line is a little broader than on the other side; but, as a similar appearance is presented by H_γ and the stronger lines of the group, it may arise from some optical or photographic cause."*

We now learn that this difference in two parts of the lines indicates a different condition of the nebula on the two sides of the star-spectra.

Other lines besides those described in this note are present, not only between G and F, but also on the more refrangible side of the strong line about λ 3725.

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* 'Roy. Soc. Proc.,' vol. 46, p. 54.

The importance of the new points which have come out from these photographs makes us regret that we must postpone a fuller examination and discussion of the spectrum of different parts of the nebula until its return next year.

ON A NEW GROUP OF LINES IN THE PHOTOGRAPHIC SPECTRUM OF SIRIUS.

WILLIAM HUGGINS, D. C. L., LL. D., F. R. S., AND MRS. HUGGINS

In 1879,* I gave an account of a series of broad lines in the photographic region of the spectrum which was found to be characteristic of Sirius, Vega, and other white stars and which was identified as a continuation of the spectrum of hydrogen beyond H.† In the photographs of Sirius which I had taken up to that time, I was not able to be certain if the two most refrangible of the lines, θ and ι, were present. This uncertainty has been set at rest by photographs taken since, in which the complete series of the hydrogen lines, including θ and ι, come out with great distinctness.

I have long suspected the presence of another group of broad lines some distance further on in the ultra-violet region, but until this year we have not been able to see them in the photographs with sufficient distinctness to be able to make even roughly approximate measures of their positions.

On April 4th, a photograph of the spectrum of Sirius was taken with a long exposure, the slit being made very narrow, in the hope of bringing out this new group of lines with greater distinctness. This plate shows, on examination, that the spectrum of Sirius, after the termination of the hydrogen series, remains, as far as we can see at present, free from any strong lines until a position as far in the ultraviolet as about λ 3338 is reached, at which place appears the first of a group of at least six lines, all nearly as broad as those of the hydrogen series. The third line of the group about λ 3278 appears to be the broadest, but they are all broad, though even in this photograph they are not seen with the distinctness which is necessary for ascertaining accurately their relative character.

* 'Phil. Trans.,' 1880, p. 669.
† H. W. Vogel 'Berlin Akad. Monatsber.,' 1879, July 10, and Cornu, 'Journal de Physique' 2nd ser. vol. 5, 1886, p. 100.

The sixth line occurs where the spectrum is faint, almost at the limit of this photograph, which was taken when Sirius was some distance past the meridian, and we are not able to find out whether this line completes the group, or whether there may be other lines still more refrangible belonging to it. We expect to be able to determine this point, namely, whether the group ends with the sixth line, when the opportunity comes round of being able to photograph the star when it is near the meridian.

The new group of six lines is well seen when the photograph is examined with a lens, but when the plate is placed under the measuring microscope it is only with some difficulty that the lines can be observed with the distinctness which is necessary for measuring them with a fair approach of accuracy.

For this reason, the wave-lengths given below must be regarded as only preliminary, and but roughly approximate measures of the positions of the new lines.

1st Line....................	λ 3338
2nd "	λ 3311
3rd "	λ 3278
4th "	λ 3254
5th "	λ 3226
6th "	λ 3199

Ten Year Catalogue of 4059 Stars deduced from observations extending from 1877 to 1886 at the Royal Observatory, Greenwich, has been received. This catalogue and the other publications that follow were made under the direction of W. H. M. Christie, Astronomer Royal, and is reduced to the epoch of 1880. It is appendix II to the Vol. of Greenwich Observations for the year 1887.

Appendix III to Greenwich Observations 1887 contains the recomputation of the position of the ecliptic, from observations of the sun, in the years 1877-1886; also, corrections to refractions of stars, sun, moon, and planets, for revised readings of the exterior thermometer, and of the barometer in the years 1877-1886.

Greenwich Magnetical and Meteorological Results for 1887 is a very useful volume, in quarto form containing 87 pages.

Greenwich Astronomical Results for 1887 presents the work of the Transit-Circle, as extracted from the work of the year. It is in convenient form for reference.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury has just passed superior conjunction and is coming towards us on the east side of the sun. It will be in excellent position for daylight observation in the northern hemisphere during the month of August. It will be at greatest elongation, east from the sun 27° on Sept. 3, and at inferior conjunction Sept. 29. Mercury will be in conjunction with Saturn, south 34′, Aug 9 at 11 P. M.

In *The Observatory*, June, 1890, Mr. W. E. Plummer gives a review of an interesting paper on "The Mass of Mercury" by Dr Haerdtl. The mass of Mercury is very difficult to determine, since it has no satellite, and the values determined from the pertubations of comets, especially Encke's comet, vary widely. Dr Haerdtl, however, by methods differing from those used before, has obtained quite accordant values from different sources

I	Mass of Mercury	$\frac{1}{5012842}$	from Winnecke's Comet.
II	" "	$\frac{1}{5514700}$	Le Verrier's equation modified
III	" "	$\frac{1}{5584600}$	Encke's Comet, 1819-1868
IV	" "	$\frac{1}{5660700}$	Encke's Comet, 1871-1885

The fractions express the ratio of the mass of Mercury to that of the sun.

Venus is growing still more brilliant in the evening sky, about seven-tenths of her disk being illuminated. She is approching the earth rapidly so that the increase in size of the disk more than compensates for the loss of light from the phase. Venus will be at greatest elongation east from the sun 46° 34′, Sept. 23. She will be in conjunction with Uranus, south 2° Sept. 2, at 5 P. M.

Mars has passed his best position for observation this year, but good views may be obtained during the next two months. His course in the sky will be almost due east, from the middle of Scorpio to the middle of Sagittarius. Mars will be in quadrature 90° east from the sun Sept. 21 and at his greatest southern latitude Sept 27. An interesting article entitled "La Geologie et la Planete Mars," by M. Daubree, is contained in the June 1890, number of *L'Astronomie*. It gives the description of a number of experiments made by M Daubree to explain the formation of the so-called "canals" on Mars, regarding them as fissures or folds in the crust of the planet.

Jupiter is now in its best position for observation during this year, rising at about 7 p. m., and setting at about 5 a. m. Its southern declination prevents it from reaching a very great altitude in nothern latitudes so that the most perfect views can not be obtained here. It will describe a very short retrograde path in the head of Capricorn during the two months. A long article, well illustrated and very interesting, on the planet Jupiter, by M Camille Flammarion is contained in *L'Astronomie*, Oct. and and Nov., 1889, and March and June, 1890. The same journal for June, 1890, contains an interesting note by M. J. Guillaume, observer at Peron

nas, on the doubling of the shadow of Jupiter's second satellite. A second shadow fainter than the ordinary one was seen to the north of, and partly covered, by the first.

Saturn will be in conjunction with the sun August 30 and so will not be visible during the next two months. *Bulletin Astronomique*, April, 1890, contains an extensive article by M. E. L. Trouvelot on the phenomena observed on Saturn about the epoch of the passage of the sun and earth by the plane of its rings in 1877-1878. This article is interesting and valuable in view of the similar phenomena which are to occur in 1891.

Uranus is getting too far west in the evening to admit of good observation. He is in Virgo northeast of Spica, about 1° south of the fifth magnitude star *m* Virginis. M. Perrotin, with the 30-inch equatorial at Nice, has been able to detect dark bands upon Uranus similar to those upon Jupiter (*L'Astronomie*, June, 1890, page 231). He finds the position angle of these bands to be about 25°, differing little from the plane of the satellite orbits. These bands do not always present the same aspect; they vary in number and width in different parts of the circumference of the planet. There is a possibility of determining from these varying aspects of the bands the time of the planet's rotation, which is now unknown. M. Perrotin also finds by careful measures that the flattening of the poles of Uranus is not less than $\frac{1}{26}$.

Neptune may be found after midnight in Taurus northwest of Aldebaran, about 1° north and 30′ east of the fourth magnitude star Epsilon Tauri. There will be an occultation of Neptune on the morning of August 9, but the planet will probably be too faint to be seen near the moon.

MERCURY.

	R. A. h m	Decl. ° ′	Rises. h m	Rransits. h m	Sets. h m
Aug. 25	11 51.2	− 0 13	7 32 A. M.	1 35.1 P. M.	7 38 P. M.
Sept. 5	12 32.5	− 6 29	7 55 "	1 33.1 "	7 11 "
15	12 50.4	− 9 35	7 36 "	1 11.6 "	6 37 "
25	12 35.0	− 7 28	6 43 "	12 17.0 "	5 51 "
Oct. 5	12 03.6	− 0 52	5 06 "	11 06.3 A. M.	5 06 "
15	12 18.3	− 0 02	4 38 "	10 41.7 "	4 45 "

VENUS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Aug. 25	13 00.6	− 7 19	9 10 A. M.	2 44.3 P. M.	8 19 P. M.
Sept. 5	13 44.2	−12 36	9 32 "	2 44.5 "	7 57 "
15	14 23.8	−16 59	9 51 "	2 44.7 "	7 39 "
25	15 03.0	−20 48	10 08 "	2 44.5 "	7 21 "
Oct. 5	15 41.0	−23 54	10 22 "	2 43.1 "	7 04 "
15	16 16.2	−26 11	10 30 "	2 38.9 "	6 48 "

MARS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Aug. 25	16 46.4	−25 25	2 16 P. M.	6 29.5 P. M.	10 43 P. M.
Sept. 5	17 12.6	−25 55	2 02 "	6 12.4 "	10 23 "
15	17 38.7	−26 08	1 50 "	5 59.0 "	10 08 "
25	18 06.4	−26 03	1 38 "	5 47.4 "	9 57 "
Oct. 5	18 35.3	−25 39	1 25 "	5 37.1 "	9 49 "
15	19 05.1	−24 54	1 12 "	5 27.5 "	9 43 "

JUPITER.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Aug. 25	20 26.4	−20 02	5 29 P. M.	10 08.9 P. M.	2 49 A. M.
Sept. 5	20 22.5	−20 15	4 43 "	9 21.8 "	2 01 "
15	20 20.2	−20 23	4 02 "	8 40.2 "	1 18 "
25	20 19.2	−20 26	3 22 "	7 59.8 "	12 38 "
Oct. 5	20 19.6	−20 24	2 43 "	7 20.8 "	11 59 P. M.
15	20 20.2	−20 18	2 05 "	6 43.2 "	11 22 "

1890.	R. A. h m	Decl ° ′	Rises h m	Transits h m	Sets h m
			SATURN.		
Aug. 25	10 36.0	+10 32	5 35 A. M.	12 20.2 P. M.	7 06 P. M.
Sept. 5	10 41.2	+10 02	4 58 "	11 42.1 A. M.	6 26 "
15	10 45 9	+ 9 34	4 26 "	11 07.6 "	5 49 "
25	10 50.5	+ 9 07	3 53 "	10 32.9 "	5 13 "
Oct. 5	10 55.0	+ 8 42	3 20 "	9 58.0 "	4 36 "
15	10 59.2	+ 8 17	2 47 "	9 22.9 "	3 59 "
			URANUS.		
Aug. 25	13 29.3	− 8 46	9 44 A. M.	3 13.1 P. M.	8 42 P.
Sept. 5	13 31.3	− 8 58	9 04 "	2 31.8 "	8 00 "
15	13 33.3	− 9 10	8 27 "	1 54.5 "	7 22 "
25	13 35.5	− 9 23	7 51 "	1 17.3 "	6 43 "
Oct. 5	13 37.8	− 9 36	7 15 "	12 40.3 "	6 05 "
			NEPTUNE.		
Aug. 25	4 20.8	+19 51	10 35 P. M.	6 02.0 A. M.	1 29 P
Sept. 5	4 21.1	+19 51	9 52 "	5 19.0 "	12 46
15	4 21.0	+19 51	9 13 "	4 39 6 "	12 06
25	4 20.8	+19 50	8 33 "	4 00.1 "	11 27 A
Oct. 5	4 20.3	+19 48	7 54 "	3 20.2 "	10 47
15	4 19.6	+19 46	7 14 "	2 40.2 "	10 07
			THE SUN.		
Aug. 25	10 17.7	+10 37	5 15 A. M.	12 01.8 P. M.	6 49 P
Sept. 5	10 57.6	+ 6 39	5 28 "	11 58.8 A. M.	6 29
15	11 33.6	+ 2 51	5 40 "	11 55.1 "	6 11
25	12 09.6	− 1 02	5 51 "	11 51.5 "	5 52
Oct. 5	12 45.8	− 4 55	6 03 "	11 48.3 "	5 33
15	13 22.6	− 8 42	6 16 "	11 45.8 "	5 16
			THE MOON.		
Aug. 20	13 43.3	− 6 16	9 52 A. M.	3 46.6 P. M.	9 31 P.
25	18 23.6	−24 32	3 39 P. M.	8 06.3 "	12 31 A
30	23 42 9	− 7 12	7 27 "	1 06 3 A. M.	6 53
Sept. 5	5 07 5	+22 43	10 17 "	6 05 4 "	2 00 P
10	8 43.2	+22 01	1 30 A. M.	9 24.8 "	5 12
15	12 41 9	+ 0 32	6 39 "	1 03 2 P. M.	7 15
20	16 58.3	−22 29	12 20 P. M.	4 59.2 "	9 33
25	22 15.2	−15 57	4 54 "	9 55.6 "	3 06 A
30	2 54 2	+13 52	7 11 "	2 14 2 A. M.	9 25
Oct. 5	7 30.9	+24 40	10 24 "	6 30.5 "	2 34 P
10	10 52.6	+ 12 36	2 24 A. M.	9 36.0 "	4 37
15	14 50.3	−13 33	7 50 "	1 13.3 P. M.	6 27

Occultations Visible at Washington.

Date		Star's Name	Magnitude.	Wash Mean T h m	Angle f'm N P't °	Wash. Mean T h m	Angle f m N P't °	Du[ration] h
Aug	23	ω Ophiuchi	4½	10 42	75	11 40	301	0
	24	*b* "	5 var	8 08	117	9 24	200	1
	24	c^2 "	[illegible]	11 00	43	11 44	320	0
	25	λ Sagittarii	3	7 28	98	8 50	270	1
	26	h^2 "	4½	9 40	60	10 53	281	1
	26	h^1 "	6	9 59	351	Star 0 6′ N of moon's li		
	29	r^1 Aquarii *mult*	5½	10 47	113	11 34	189	0
	29	r^2 "	4	11 59	69	13 11	226	1
Sept.	5	*i* Tauri	5	12 08	110	12 52	210	0
	22	ψ Sagittarii	5½	10 25	55	11 24	282	1
	27	B. A. C. 17	6	8 13	73	9 21	225	1
	28	29 Ceti	6½	11 34	348	12 04	300	0
	28	33 Ceti	6	13 15	359	13 59	289	0
	28	35 Ceti	6½	13 57	63	15 09	229	1
Oct.	2	W. iv, 650	6	9 20	79	10 15	240	0

Phases of the Moon.

			Central Time. d	h	m
First Quarter.............................	1890	Augt	23	7	20 A. M.
Full Moon.............................	"	"	29	10	35 P. M.
Last Quarter.............................	"	Sept	5	9	29 "
New Moon.............................	"	"	14	1	53 A. M.
First Moon.............................	"	"	21	4	05 P. M.
Full Moon.............................	"	"	28	1	00 A. M.
Last Quarter.............................	"	Oct	5	2	23 P. M.
New Moon.............................	"	"	13	5	05 "

Phenomena of Jupiter's Satellites.

Central Time. d.	h. m.			
ug. 16...	8 32	P.M.	I.	Tr. In.
	8 58	"	I.	Sh. In.
	10 52	"	I.	Tr. Eg.
	11 18	"	I.	Sh. Eg.
17...	8 36	"	I.	Ec. Re.
18...	9 25	"	II.	Oc. Dis.
20...	8 24	"	II.	Sh. Eg.
23...	12 50	A.M.	III.	Oc. Dis.
	10 16	P.M.	I.	Tr. In.
	10 53	"	I.	Sh. In.
24...	12 36	A.M.	I.	Tr. Eg.
	7 36	P.M.	I.	Oc. Dis.
25...	7 43	"	I.	Sh. Eg.
	11 42	"	II.	Oc. Dis.
26	8 49	"	III.	Sh. Eg.
27	8 07	"	II.	Sh. In.
	9 39	"	II.	Tr. Eg.
	11 02	"	II.	Sh. Eg.
31	12 03	A.M.	IV.	Sh. Eg.
	12 03	"	I.	Tr. In.
	12 48	"	I.	Sh. In.
	9 22	P.M.	I.	Oc. Dis.
pt. 1...	12 27	A.M.	I.	Ec. Re.
	7 17	P.M.	I.	Sh. In.
	8 49	"	I.	Tr. Eg.
	9 37	"	I.	Sh. Eg.
2...	6 55	"	I.	Ec. Re.
	9 09	"	III.	Sh. In.
	9 33	"	III.	Tr. Eg.
5...	7 46	"	II.	Ec. Re.

Central Time. d.	h. m.			
Sept. 7...	6 56	P. M.	IV.	Oc. Dis.
8...	8 16	"	I.	Tr. In.
	9 12	"	I.	Sh. In.
9...	8 50	"	I.	Ec. Re.
	9 22	"	III.	Tr. In.
13...	6 51	"	III.	Ec. Re.
15...	10 04	"	I.	Tr. In.
16...	7 25	"	I.	Oc. Dis.
17...	6 51	"	I.	Tr. Eg.
	7 56	"	I.	Sh. Eg.
19...	7 55	"	II.	Oc. Dis.
20...	7 20	"	III.	Ec. Dis.
21...	8 12	"	II.	Sh. Eg.
23...	9 15	"	I.	Oc. Dis.
24...	7 31	"	I.	Sh. In.
	8 41	"	I.	Tr. Eg.
	9 38	"	IV.	Ec. Dis.
	9 51	"	I.	Sh. Eg.
25...	7 10	"	I.	Ec. Re.
26...	10 22	"	II.	Oc. Dis.
27...	10 08	"	III.	Oc. Re.
28...	7 53	"	II.	Sh. In.
	8 23	"	II.	Tr. Eg.
Oct. 3...	6 15	"	I.	Sh. Eg.
5...	7 59	"	II.	Tr. In.
7...	7 33	"	II.	Ec. Re.
9...	7 26	"	I.	Oc. Dis.
10...	6 54	"	I.	Tr. Eg.
15...	7 38	"	III.	Tr. Eg.

COMET NOTES.

Comet 1890......(Brooks March 19). This comet is visible, with the id of a small telescope, in the evening. It is in the constellation *Canes 'enatici*, and moving in a southwesterly direction. The following rough phemeris, given by Herr Bidschof (A. N. 2970) shows, that this comet will e visible the remainder of this year and part of next year.

1890-91.	α	δ	log r	log Δ	Brightness.
June 30	$14^h\ 44^m.6$	$+61°\ 57'$	0.2881	0.2511	2.68
Aug. 1	13 11 .0	45 38	.3121	.3714	1.38
Sept. 2	12 59 .9	34 56	.3470	.4604	0.78
Oct. 4	13 04 .9	28 49	.3872	.5058	0.53
Nov. 5	13 11 .0	26 03	.4288	.5118	0.42
Dec. 7	13 08 .0	26 31	.4694	.4852	0.40
Jan. 8	12 42 .5	+30 21	0.5080	0.4422	0.40

Elements and Ephemeris of Comet a 1890 (Brooks March 19.) From my own observations of March 21, April 21 and May 24, I have computed the following elements and ephemeris:

$$T = 1890, \text{June } 1\ .15896 \text{ Gr. M. T.}$$
$$\pi = 29^\circ\ 2'\ 15''.5$$
$$\omega = 320\ 18\ 55\ .6$$
$$i = 120\ 30\ 56\ .5$$
$$\log q = 0.280830 \qquad p = 1.90612$$

Gr. M. T.	App. R. A. h m	App. Dec. ° ′	Log. r.	Log. Δ.
Aug. 1.5	13 11.3	+ 45 39	0.3126	0.3718
2.5	10.4	45 14		
3.5	9.5	44 48		
4.5	8.7	44 24		
5.5	7.9	43 59	0.3166	0.3852
6.5	7.2	43 36		
7.5	6.5	43 12		
8.5	5.9	42 49		
9.5	5.3	42 26	0.3206	0.3982
10.5	4.8	42 4		
11.5	4.3	41 42		
12.5	3.9	41 20		
13.5	3.5	40 59	0.3248	0.4103
14.5	3.1	40 38		
15.5	2.7	40 17		
16.5	2.4	39 57		
17.5	2.1	39 36	0.3292	0 4218
18.5	1.8	39 16		
19.5	1.5	38 57		
20.5	1.3	38 39		
21.5	1.1	38 20	0.3336	0.4325
22.5	0.9	38 2		
23.5	0.7	37 44		
24.5	0.6	37 26		
25.5	0.5	37 8	0.3381	0.4427
26.5	0.4	36 51		
27.5	0.3	36 34		
28.5	0.3	36 18		
29.5	0.2	36 1	0.3428	0.4520
30.5	0.2	35 45		
31.5	13 0.2	+ 35 29		

O. C. WENDELL.

Harvard College Observatory, July 2, 1890.

Bright Meteor. On the evening of May 23 last, at 7^h^ 10^m^ Eastern standard time, I saw a brilliant meteor of dazzling lustre, white with a bluish tinge, pass across the heavens. The sun was still shining brightly and the sky cloudless. The motion of the meteor was comparatively slow, nearly horizontal, 4° degrees above the horizon, and covered less than 10°. Its mean direction was S. 24° E. The meteor was followed by a disconnected or broken train about 2° in length, inferring therefrom an actual combustion and not only an optical illusion. The phenomena ceased before reaching the horizon. O. M. J. KLOTZ.

Preston, Ontario, May 27, 1890.

Prominences in May. Number of observations, 17; number of prominences, 74; mean number of prominences 4.35; greatest number in one day, 7 (on 2d, 18th and 31st); highest prominences, 29th (58″).

DISTRIBUTION OF PROMINENCES.

	E. Limb.	W. Limb.		E. Limb.	W. Limb.
0 to 10	11	1	0 to — 10	9	4
10 to 20	3	2	— 10 to — 20	0	0
20 to 30	1	3	— 20 to — 30	0	4
30 to 40	2	0	— 30 to — 40	0	1
40 to 50	1	0	— 40 to — 50	1	2
50 to 60	1	0	— 50 to — 60	0	0
60 to 70	0	0	— 60 to — 70	0	1
70 to 80	6	0	— 70 to — 80	0	4
80 to 90	8	1	— 80 to — 90	4	4
				47	27

Camden Observatory, June 1, 1890.

Prominences in June 1890. Nnmber of observations, 19; number o prominences, 57; mean number of prominences, 3; highest prominence, 60″ (on the 29th inst.).

DISTRIBUTION OF PROMINENCES.

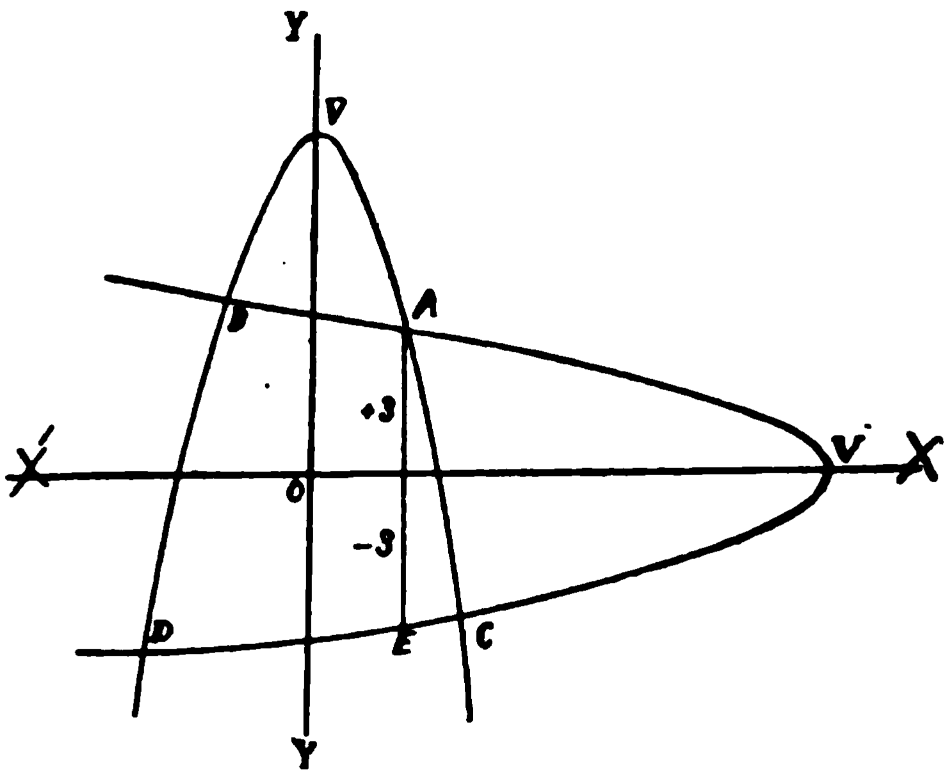
Between	E. Limb.	W. Limb.	Between	E. Limb.	W. Limb.
0 and + 10	2	0	0 and — 10	0	2
+ 10 and + 20	5	2	— 10 and — 20	0	5
+ 20 and + 30	3	0	— 20 and — 30	0	1
+ 30 and + 40	1	1	— 30 and — 40	0	0
+ 40 and + 50	3	5	— 40 and — 50	1	1
+ 50 and + 60	0	11	— 50 and — 60	4	2
+ 60 and + 70	0	0	— 60 and — 70	4	0
+ 70 and + 80	0	2	— 70 and — 80	0	0
+ 80 and + 90	0	2	— 80 and — 90	0	0
				23	34

Camden Observatory, July 1, 1890.

Carleton College Sunspot Observations. Continued from page 180.

Date	Central Time.	Groups	Spots	Faculae	Observer	Remarks.
1880						
May 31.	12.35 P. M.	0	0	1 gr.	C. R. W.	Small gr. of fac. near W. limb.
June 3.	2.45 "	0	0	1 gr.	"	Fac. S. W.
" 7.	12.05 "	1	4		"	One large spot with fac.
" 7.	3.30 "	1	10	7 gr.	H. C. W.	5 gr. fac. near E. limb.
" 11.	8.45 A. M.	0	0	1 gr.	C. R. W.	
" 16.	4.30 P. M.	1	2	2 gr.	"	Spots very poorly defined.
" 17.	2.50 "	0	0	1 gr.	"	One very brilliant fac. S.
" 18.	3.55 "	0	0	1 gr.	"	Faculae S. W.
" 21.	5.20 "	0	0	1 gr.	"	
" 24.	3.45 "	0	0	3 gr.	H. C. W.	
" 25.	12.40 "	0	0	1 gr.	"	
" 26.	11.40 A. M.	0	0	1 gr.	C. R. W.	Faculae S.
" 27.		0	0	2 gr.	"	
" 28.	12.20 P. M.	0	0	1 gr.	"	Faculae S. E.
July 4.	10.30 A. M.	1	1	1 gr.	"	Spot in S. E. surrounded by fac.
" 7.	8.45 "	1	16	1 gr.	"	
" 8.	2.00 P. M.	1			"	
" 9.	12.39 "	1	10	0 gr.	H. C. W.	
" 10.	4.15 "	1	6	0 gr.	C. R. W.	
" 14.	10.10 A. M.	1	2	2 gr.	"	Spot near W. limb, followed by long and narrow gr. of fac. Group of fac. near E. limb.

A Graphic Solution of the Equations, $x^2 + y = 7$; $x + y^2 = 11$. $x^2 + y = 7$ is the equation of a parabola whose vertex v is a distance of 7 above the origin o, and $x + y^2 = 11$ is the equation of a parabola whose vertex v is a distance of 11 to the right of the origin.



If, in each equation, we give values to one letter, and find the corresponding values of the other letter, and then trace curves through the points of which these values of x and y are the co-ordinates, the curves will intersect each other in the four points A, B, C, D. If now the co-ordinates of these points be measured they will be found to be, respectively, $x = 2$, $y = 3$; $x = -1.8$, $y = 3.6$; $x = 3.1$, $y = -2.8$; $x = -3.3$, $y = -3.8$. These values, found by measurement, are, approximately, the values given by Mr. Keith and Mr. Coakley, in their solutions published in Number 80 of the MESSENGER.

(It is interesting to note that, in the equations $x + y^2 = 11$, when x is 2, y has two values $+3$ and -3. The algebraic solution gives only one of these values. The diagram shows that the graphic solution tells the same story, for the point E, whose ordinate is -3, is on only one curve, and hence this value y could not satisfy both equations.)

Garfield University. W. A. CRUSINBERRY.

Given the equations

$$x^2 + y = 11 \qquad (1)$$

$$x + y^2 = 7 \qquad (2)$$

From (1)

$$x^2 - 9 = 2 - y \qquad (3)$$

From (2)

$$x - 3 = 4 - y^2 \qquad (4)$$

Dividing (3) by (4), thus taking out the root factors $x - 3$ [and $2 - y$]

$$x - 3 = \frac{1}{2 + y} \qquad (5)$$

whence

$$xy + 2x + 3y + 5 = 0 \qquad (6)$$

If (6) is combined with either (1) or (2) and y is eliminated, then in either case, the degree of the resultant equation rises only to the third, the equation will be

$$x^3 + 3x^2 - 13x - 38 = 0 \qquad (7)$$

just as it should be. In the same way, if, after combining (6) with (1) or (2), x is eliminated it is only possible to find

$$y^3 + 2y^2 - 10y - 19 = 0 \qquad (8)$$

and so far, nothing new is shown.

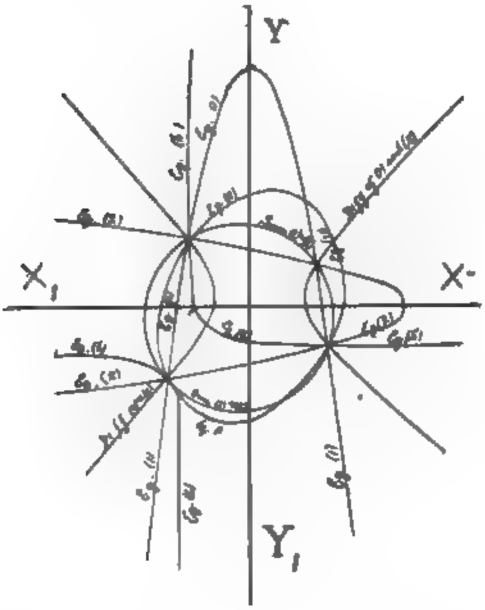
ow, if instead of taking the given equations singly, they are com- before comparing with equation (6), an infinite number of false com- urable roots can be produced. Thus if the given equations are added ombined with (6), there is produced

$$x^4 + 7x^3 - x^2 - 90x - 152 = 0 \qquad (9)$$

1 has a root $x = -4$, the corresponding value of y being -3. Had given equations been subtracted and then compared with (6), it is l

$$x^4 + 5x^3 - 7x^2 - 64x - 76 = 0 \qquad (10)$$

which it can be found that $x = -2$, the corresponding value of y -1.



homogeneous equation

$$3x^2 - xy + 2y^2 = 52 \qquad (11)$$

e produced by adding three times (1) to two times (2) and subtract- 5) from this sum; and by means of this homogeneous, it can be proved nple reasoning that the complete solution of the original equations by ratics is impossible. If No. (11) is combined with any of the preceding ions a false root is obtained in each case.

he following graphic representation of these equations will probably it clearer:

quation (1) is a parabola with the vertex at (0, 11); (2) is a para- with vertex at (7, 0); the sum of (1) and (2) is a circle with center ½, — ½): the difference of (1) and (2) a hyperbola with center at ₂); equation (6) is a hyperbola with center at (— 3, — 2) asymtotes

parallel to the axes; equation (11) is an ellipse with center at the origin, the transverse axis inclined 67° 30′ to the axis of x positive.

Where do the false roots come from? Of course from a mistake in the work; the error does not appear in equation (6) but arises from adding, subtracting and otherwise combining equations (1) and (2).

NEWS AND NOTES.

The next number of this journal will be published for the month of October, and numbers will follow consecutively for each month thereafter.

•We have given this month unusual space to the important studies in spectroscopic lines as presented in the extended papers by Dr. Huggins and Mrs. Huggins. These articles and that of Mr. Monck, bearing also on the use of the spectroscope, have, in part, taken the place of the usual biographical sketch.

Teneriffe, Alta-Vista, Tyde is the title of an article from the pen of Mr. D. W. Edgecomb, recently received. It contains useful information gathered in foreign travel. It will appear in the next MESSENGER.

Harvard College Observatory Photographic Work. Some time ago, Professor William H. Pickering favored us with some fine photographs of Saturn, Jupiter, and the Great Nebula surrounding η Argus. The picture of Jupiter is a beautiful one. It was taken at Mt. Wilson, California, 1889, July 12. 19^h 38^m G.M.T., the altitude of the station being 6,200 ft. Its scale is $\frac{1}{5000000000}$ or $1''.65 = 1^{mm}$, magnified (at 29 c. m. distance), 450 times. The 13-inch telescope was used and the exposure was 87 seconds. Jupiter's system of belts is surprisingly distinct.

The exposure for Saturn was made at the same place, 1890, Feb. 7, 18^h 54^m, G. M. T.; scale $\frac{1}{50000000000}$ or $0''.94 = 1^{mm}$, magnified 770 times, same instrument, with an exposure of 6^m 16^s. Though the picture of Saturn is not quite as sharp as that of Jupiter, yet the dark ring, the bands of the planet, and the division of the rings at the ansæ are features more or less easily seen.

The picture of the Great Nebula surrounding η Argus, was taken 1889, June 16, 12^h 17^m, siderial time scale $60'' = 1^{mm}$, magnified 12 times, the 8-inch Batche camera being used. The exposure was made at Mt. Howard, Penn., and was one hour long. The altitude of this station was 6,600.

Professor Pickering has also kindly sent us some prints of plates prepared for future parts of the *Annals*, which plainly show some of those interesting discoveries by the aid of photography which have been previously noticed in this journal. We are pleased to announce that some of these fine plates are to be reduced, or to appear without change in THE MESSENGER as soon as they are ready for publication. The engrossing interest that attaches to this feature is well shown by the fact that Professor Pickering's late pictures of the great Special Nebula show a change in form from that seen in Mr. Common's photographs of Jan. 30, 1883.

Aid to Astronomical Research. Miss C. W. Bruce offers the sum of six thousand dollars ($6,000) during the present year in aiding astronomical research. No restriction will be made likely to limit the usefulness of this gift. In the hope of making it of the greatest benefit to science, the entire sum will be divided, and in general the amount devoted to a single object will not exceed five hundred dollars ($500). Precedence will be given to institutions and individuals whose work is already known through their publications, also to those cases which cannot otherwise be provided for or where additional sums can be secured if a part of the cost is furnished. Applications are invited from astronomers of all countries, and should be made to the undersigned before October 1, 1890, giving complete information regarding the desired objects. Applications not acted on favorably will be regarded as confidential. The unrestricted character of this gift should insure many important results to science, if judiciously expended. In that case it is hoped that others will be encouraged to follow this example, and that eventually it may lead to securing the needed means for any astronomer who could so use it as to make a real advance in astronomical science. Any suggestions regarding the best way of fulfilling the objects of this circular will be gratefully received.

Harvard College Observatory, EDWARD C. PICKERING.
Cambridge, Mass., U. S. A., July 15, 1890.

We are glad to give place, in THE MESSENGER, to this circular, for we are sure it will greatly interest our readers and stimulate endeavor in many needy and useful lines of astronomical research. Miss C. W. Bruce has taken a high and noble stand in favor of astronomical science, and her late munificent gifts to it are not only a blessing to Harvard College Observatory, but to American astronomy as well. Professor Pickering is to be congratulated in having such generous and intelligent aid as that which Miss Bruce furnishes for his own and other lines of astronomical study.

Motion of the Atmosphere above the Highest Clouds. The fall of the meteorite in Northern Iowa on May 2d, as noticed in the last number of this journal, has aroused great interest in such phenomena. There is a single point in this connection that should be emphasized, and possibly from this fall or others in the future, facts of the highest importance may be gleaned. It is known probably to all that we have practically no reliable information as to the direction of motion or velocity of atmospheric current above our highest clouds. The rather startling theory has been advanced to explain the sky glows of 1883 and later years, that the upper currents at 20 miles above the earth move from east to west at a velocity of 80 miles per hour, but it is very doubtful if any current exists except one moving very slowly towards the east. Whenever a meteor leaves behind a more or less permanent cloud or smoke its motion ought to elucidate this problem. A velocity of even 40 miles per hour would be detected at once at the earth, but if the motion is very slow it could be determined only by watching the trail as it moved across the point of a high building or a tree, the eye being held perfectly stationery. If there are light fleecy clouds in the sky at a lower level great care would be needed to distinguish be-

tween their motion and that of the meteor trail. In this case it will be very necessary to watch the trail by having its line of sight pass through a high point. If the trail is more than 45° from the zenith it will be practically impossible to tell the direction unless it continues a very long time, which it usually does not do. A single careful observation of the direction of such a trail through or near one's zenith would be of the highest value.

Washington, D. C., June 7, 1890. H. A. HAZEN.

The Latest Latitude Result at Greenwich.—In the report presented by the Astronomer Royal to the Board of Visitors on June 7, 1890, appears the following paragraph:

"The co-latitude of the transit-circle as found from the observations of 1889 is 38° 31′ 23″.05, differing by + 0″.15 from the adopted value."

The full importance of this sentence does not appear on the surface. It may be necessary to recall that the modern study of the Great Pyramid has raised, since 1867 A. D., the question, whether there is not a minute change in the latitude of places, unpointed to as yet by Gravitational Astronomy, but always going on, and amounting at the Great Pyramid to 69″ of decrease in the course of 4,000 years.

On one side this conclusion has been taken up positively by Mr. A. A. Anderson, in his weighty little book entitled "Terra," and considered explanatory of geological changes of still higher secular periods, which he has found identifiable over nearly the whole earth's solid surface. But on the other side, the very possibility of such an alteration of latitude has been contemptuously denied; and though the other Greenwich observations have been quoted* as showing a very similar alteration there, or thus—

In 1766, Lat. = 51° 28′ 40″.0
In 1834, " 51° 28′ 39″.0
In 1856, " 51° 28′ 38″.2 and
In 1880, " = 51° 28′ 38″.1

that was considered so much the worse for them.

But now if we apply to the end of the above series the last, the supposed best and the yet unchallenged result, or that given in the quotation already referred to, turning its co-latitude into latitude, there appears for 1889 just 51° 28′ 37″.95.

That is a still further change since 1880, but in the *same* direction as before; and amounting to 0″.15 in nine years, or 66″ in 4,000 years. Which is surely as close a confirmation of the pyramid quantity of 69″ in the same length of time, as any one could have possibly expected, and it is at least very curious that every successive latitude result at the Royal Observatory will persist in showing a smaller and smaller figure.

June 27, 1890. C. P. S.

U. S. Scientific Expedition to West Africa. Bulletins numbered 15 and 18, under dates respectively April 19, 1890, and May 15, 1890, of the above named expedition have been received. The title of the first is The Law of Distribution of the Actinic Light of the Solar Corona, and that of the second is Terrestrial Magnetism. Both are prepared by Professor Frank H. Bigelow, of Washington, D. C.

* See "Our Inheritance in the Great Pyramid," 5th edition, page 62.

U. S. Naval Observatory Time. Memorial to the Secretary of the Navy. April 15, 1890. To the Secretary of the Navy: Sir: Your attention is hereby respectfully called to the injury inflicted upon various Astronomical Observatories in the United States by a practice which has been established at the U. S. Naval Observatory of supplying the Western Union Telegraph Co. with time signals for commercial use.

For a considerable number of years the signals necessary for the regulation of time-pieces have been derived, in different parts of the country, from the Observatories established in those districts. The sums received in payment for the signals have formed an important portion of the revenues by which the Observatories have been supported. An additional advantage resulting to the Observatories from this system consists in the fact that it thus becomes apparent to the people of each district that the Observatory founded among them is rendering a constant public service. They are consequently led to take a more active interest in astronomical science than would otherwise be the case, and the Observatories must depend upon this interest for the donations and legacies by means of which their scientific researches are supported.

But these astronomical institutions are unfitted for commercial competition with a powerful corporation like the Western Union Telegraph Co. If this corporation undertakes to occupy the field of supplying time signals, and can obtain the same gratuitously from the U. S. Naval Observatory, it is obvious that the local Observatories must abandon the contest, with great damage to their means of support, both direct and indirect, as has been shown above. Such is the actual result of the present policy of the Western Union Telegraph Co., to succeed in which, however, it depends upon the support which it now actually obtains from the U. S. Naval Observatory. That Observatory, founded to promote the science of astronomy in this country, now accordingly appears as the means of withdrawing the funds which have hitherto been maintaining that science in many parts of the United States.

The arrangement between the U. S. N. Observatory and the Western Union Telegraph Co. contemplates the distribution of time signals from the Naval Observatory to the entire country. Beside the injustice to private Observatories already alluded to, this plan involves difficulties which will make any such service uncertain and inaccurate as compared with the present automatic service from the private Observatories.

You are therefore requested, by this memorial, to consider the system which has been established at the U. S. Naval Observatory, in pursuance of which time signals are given, for commercial use, to the Western Union Telegraph Co., and to cause this practice to cease if you find that it is injurious to the interests of American astronomy. Very respectfully, Edward C. Pickering, Director Harvard College Observatory, Cambridge, Mass.; John K. Rees, Director Columbia College Observatory, New York, N. Y.; G. W. Hough, Director Dearborn Observatory, Evanston, Ills.; Edward S. Holden, Director Lick Observatory, Mount Hamilton, Cal.; Ormond Stone, Director Leander McCormick Observatory, Charlottesville, Va.; Wm. W. Payne, Director Carleton College Observatory, Northfield, Minn.; Frank W. Very, Allegheny Observatory, Allegheny, Pa.; C. A. Young, Director Halstead

Observatory, Princeton, N J; Carr W Pritchett, Director Morrison Observatory, Glasgow, Mo, Winslow Upton Director Observatory Brown University, Providence, R I, Lewis Swift, Director Warner Observatory Rochester, N. Y; H A. Howe, Director Chamberlain Observatory, Denver, Col, J. G Porter, Director Cincinnati Observatory Cincinnati, O, W. B Smith, Director Observatory University of Missouri, Columbia, Mo, H S Pritchett, Director Observatory Washington University St Louis, Mo H A. Newton, Director Winchester Observatory, Yale University New Haven, Conn, E Colbert, Chicago Tribune, formerly Superintendent Dearborn Observatory, Chicago, Ills, Chas A Bacon Director Smith Observatory, Beloit, Wis., Wm A Rogers Director Shannon Observatory Colby University, Waterville, Maine Edwin Brant Frost, Director Shattuck Observatory, Dartmouth College, Hanover, N. H Charles Burckhalter Director Chabot Observatory, Oakland, Cal and others whose names have been forwarded to Washington

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The above memorial was placed in the hands of Secretary Tracy several weeks ago, and it is reported that he is in correspondence with the officers of the Western Union Telegraph Company Some of the persons whose names were signed to this memorial have had conference with the telegraph company, upon the points raised in it, and in every case obtained no satisfaction whatever We do not expect anything favorable will come of this attempt, for we know too well the present strained relations that exist between the telegraph company and the Government, to believe that it will amount to anything If this step fails, others will be tried and the case will not be relinquished until justice is done in some way

The Largest Glass Yet is the title of an article in the *Boston Evening Transcript* (May 24) which described the latest undertaking of Alvan Clarke's Sons in the manufacture of great telescopes. The point of the article seems to be to call attention to the Clarkes as the great makers of telescopes in the world, and that they have the contract for making the 40-inch glass for the University of the Pacific, for the talked-of site of Wilson's Peak, near Los Angeles, California After speaking of the large telescopes that the Clarkes have made, the peculiar genius, in optical lines, with which these makers have been endowed is set out in plain and very complimentary way, and under this head the following statement occurs.

In all the arts there are those who have skill and those who have genius The skillful optician would go to work and mathematically figure the curves of the glasses, and if the calculations were correct the lens would be good. The genius fashions it out with but the incidental use of measurements, depending upon his eye and judgment, which are more unerring than mathematics. The Clarkes belong to the order of genius.

The article closes with the following rather caustic sentence

Mr Clarke has insisted that he shall have the mounting of the new telescope, so that the blundering that took place in the instance of the Lick telescope, and which necessitated his finally being called upon shall not be repeated.

This article is editorial in form, and doubtless was written by some ambitious reporter who wished to pay the Clarkes a handsome compliment

without their knowledge, for it is not conceiveable they would have permitted such things to be said if they had known it beforehand. All scientists well know that the Clarkes are justly celebrated for the work they have done, in producing the finest, the largest and the most powerful telescopes in the world. But the ardent reporter is evidently out of his sphere when he attempts to define and classify these high orders of genius and pronounce definitely upon their respective ranks in the scale. Is he not a little too previous when he claims supremacy for a method used by the Clarkes, as against another and different one which science has not yet had sufficient knowledge of to estimate fairly and justly? In this he may be right or he may be wrong, nobody knows. A little patient waiting until the new method shall be tried, on large glasses, will surely furnish the needed evidence; and interested scientists will not have to wait long, for two glasses of sufficient size for a crucial test are now under way by the new method which has already somewhat disturbed friends of the old process.

In regard to the statement that Mr. Clarke has insisted that he shall have the mounting of the new 40-inch refractor, so as to prevent any such blundering as that which took place in mounting of the Lick telescope, we hasten to say, that everybody who knows the facts are greatly surprised that any such claim should be made. We have taken care to find out the facts from those unprejudiced, who were present during the setting up of the Lick telescope, and who know what mistakes were made and who made them. And it is but just to say that *no alterations whatever* were made in the mounting of the 36-inch refractor at the instance of Mr. Clarke—indeed, none have been made at all up to the present time. Professor Holden has intended to fill the iron pier with masonry, (it was Capt. Floyd's intention before the telescope was mounted), but the performance of the instrument is so satisfactory that the filling has been put off, and has not yet been done. It is not claimed that improvements could not be made in the mounting, now that the astronomers have had the opportunity of using it for a couple of years, but the requirements which the makers were given in advance were certainly admirably fulfilled by them. The mere fact that a single person can manage the instrument (dome, floor, etc.) without difficulty is sufficient testimony to the excellence of the mechanical work.

In Mr. Burnham's paper on double-star discoveries and their measures, at Lick Observatory, made in 1889 and published, in volume 38, page 81, of the proceedings of the American Association for the Advancement of Science, we find a paragraph bearing on the mounting of the instrument, which plainly shows his opinion of its chararter. He says that the micrometer, driving-clock, pier and other mechanical details are equally perfect (with the optical part of the instrument) for double star work, the severest possible test for the performance of any telescope.

Thirty-ninth Annual Meeting of the A. A. A. S. The thirty-ninth annual meeting of the American Association fcr the Advancement of Science will be held in Indianapolis, Ind., beginning August 19, 1890.

The history of this Association is an interesting one. It assumed its present name in 1848, with the various departments of science, as now

known, and a roll of membership containing 461 names comprising nearly every person of scientific note in America. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

From 1848 to 1889 inclusive there have been thirty-eight meetings of the Association. In 1871, the twentieth meeting was held at Indianapolis with a roll of 668 members and an attendance of only 196. There are now over 2,000 members and it is expected that 1,000 members and associates will be present at the meeting announced for this month at Indianapolis.

The admission fee of a new member is $5. The annual assessment is $3. All members have the privileges of the meeting alike and can present papers, enter into the discussions and vote in the general session and in the meetings of the sections which they may join. Every member who has paid his assessment receives, free, the volume of the proceedings relating to the meeting which is published after each session, and contains the addresses, reports, and papers presented before the Association.

The Association is divided into eight sections:—

Section "A," Mathematics and Astronomy; "B," Physics; "C," Chemistry; "D," Mechanical Science and Engineering; "E," Geology and Geography; "F," Biology; "H," Anthropology; "I," Economic Science and Statistics." A Vice-President presides over each section, and the President over all General Sessions and the Council. All the officers of a meeting, with the past presidents, vice-presidents of the last meeting, and a fellow elected from each section, form the Council, which has the general management of the affairs of the Association.

For general information address Alfred F. Potts, Secretary of Local Committee, Indianapolis, Ind. For information as to membership address A. W. Butler, Secretary Indiana Academy of Science, Brookville, Indiana.

Photographic Notes. Publications of the Astronomical society of the Pacific makes the following statements as to lunar photography: "It is found by experiments made on the evening of April 21st, that the dark part of the moon, when the moon's age is 2.9 days, can be photographed with the twelve-inch Equatorial with a Seed 26 plate in twenty seconds —the complete outline of the dark part just showing with this exposure. With forty seconds and seventy seconds the dark part was conspicuous and details on it more clearly shown."

Monthly Notices for May gives "Mean areas and heliographic latitudes of sunspots in the year 1889, from photographs taken at Greenwich, Dehra Dun (India), and in Mauritius."

The July number of *Knowledge* contains a beautiful photograph of the region of the Milky Way to the southwest of the Trifid Nebula, taken by Mr. Barnard. This picture is accompanied by an article on the distribution of stars in the Milky Way, by Mr. Ranyard.

America Metrological Society. We are extremely sorry that we did not find space in our last issue for the interesting report of the last meeting of the American Metrological Society at Washington, D. C., which report was furnished at our request by Secretary J. K. Rees, of Columbia College, New York City. We can now only give a portion of the address of the President, Dr. B. A. Gould, which pertains to the aims of the Society.

The aims of this Society embrace many important objects. There will, for many a long year to come, be more than enough for us to do. But we shall, of course, act most efficiently if we concentrate our efforts in a single direction at one time. And the general introduction of the metric system of weights and measures is clearly that which public sentiment indicates as the most important direction for our present exertions. If all will lend an earnest hand, and if we act wisely, success must attend our efforts.

The reception very recently, by the United States office of Weights and Measures, of the verified and authenticated prototypes of the meter and kilogram, marks an epoch in the advancement in the Metric system among us. There is now no opportunity for the smallest pretense that the standards of measures and weight are not thoroughly international. The old *metre des Archives* and *Killogramme des Archives* have now fulfilled their object, and have ceased to possess other value, even in France, than a purely historical one. There is but one legal or accepted meter and but one kilogram, and these are the international ones, sacredly and most carefully guarded in the International Bureau at Breteuil. More than twenty different nations are now provided with copies of the originals, together with official certificates of the precise amount of their variation from these; for although these variations are too small to be avoided they have yet proved measurable by the exquisitely refined methods employed. Through the courtesy of the Superintendent of the Coast and Geodetic Survey the Society is invited to inspect the prototypes to-morrow morning.

Since the metric crusade of twenty years ago, which was so nearly successful, the people of the United States have become far more thoroughly informed upon the subject; and only an earnest impulse and a judicious guidance of the movement which is urged from so many sides, now seems needed for ensuring such national action as shall place our country by the side of the vast majority of the civilized nations of the globe. The recent action of the international American conference cannot fail to afford a vigorous impulse towards such action. In a word, the time for renewed exertion seems to have arrived; and upon you, gentlemen, devolves the duty of aiding and impelling it.

There are various other matters of importance which claim the attention of our Society, and papers upon these subjects will be presented. Soon the time for action upon them will probably arrive; and the Society may be called upon to concentrate its efforts upon them in their turn. But the common accord of the great majority of those who are interested in Metrology appears to indicate the question of weights and measures as the first to be taken in hand. In this we have the sympathy of an overwhelming preponderance of the civilized inhabitants of the world. Also we have that of men of science, in the two other nations who have not yet ranged themselves in line, although the time must soon arrive when they too will

have joined the great fraternity of nations whose union on all that pertains to weights and measurement will remove another of the international barriers, which it is the glory of our century to be so rapidly removing.

Trusting that this meeting of the American Metrological Society may contribute something toward the attaining of the end so ardently to be desired, I welcome you to the first session of the Society at the National Capital.

BOOK NOTICES.

ADVANCED PHYSIOGRAPHY, by John Thornton, M. A., Head Master of Clarence Street High School, Boston, with 6 Maps, 180 Illustrations and Colored Plate of Spectra. London: Messrs. Longmans, Green & Co., and New York: 15 East 16th Street. 1890. 8vo cloth. pp. 342.

This work is a continuation of an elementary treatise on the same subject by the same author, and these books are written to supply the need apparent and as defined by what is known in London as the Syllabus of the Science and Art Department of public education. The question whether Physiography can yet be called a separate science is not discussed in this series, so far as we know, but it is, we think, properly assumed, that a well-defined and well ordered series of facts connected with the study of the universe may rightly be set forth under the new title of Physiography.

A glance at this book shows that its author has drawn freely from the work of the New Astronomy, as it is now often called, in which the telescope, the spectroscope and the sensitive plate of photography are the chief instruments of research. In other words, the leading thought is to unfold as far as known the physical constitution of the heavenly bodies and put in secondary place the study of their exact positions and movements which the Old Astronomy so strongly emphasized. This is manifestly right in the preparation of elementary books on this subject, and more will be done in the same direction, in advanced studies in Astronomy in the future by the specialist and the physicist, because a demand for it is already apparent.

The order of topics, as given in this book, is as follows: The celestial sphere, constellation definitions and explanations, general survey of the solar system, light and astronomical instruments, spectrum analysis, the physical and chemical constitution of the sun, description of the planets, the moon, its dimensions, orbit, rotation, phases, physical condition, eclipses, the tides, comets and meteors, the motions of the earth, changes in its orbit, measurement of the surface, size and shape mass, determination of latitude and longitude, celestial measurements, gravitation and celestial masses, stars and nebulæ, atmospheric and oceanic measurements, terrestrial magnetism, cosmogony, secular cooling of the earth, secular changes of climate. Then follows an appendix containing the Greek alphabet, time constants, trigonometrical functions, principal elements of the solar system, the transit circle, geological importance of tides, age of the earth, geological chemistry, and a colored plate of spectra at the end. In the appendix, we also find a set of examination papers and questions for review, which, more than any other single feature in the book, shows how this system of science and art training works. It seems to us that the author has done good work in the preparation of this text book.

Books Received.

A Handbook of Descriptive and Practical Astronomy, by George F. Chambers. (Volume) III. The Starry Heavens. 4th Edition.

New Light from Old Eclipses, by William M. Page, C. R. Barnes Publishing Co., St. Louis, Mo.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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THE STRUCTURE OF THE SIDEREAL UNIVERSE.

THOMAS WM. BACKHOUSE.

For THE MESSENGER.

This is a subject which until lately does not seem to have received much attention since the late R. A. Proctor's "The Universe" appeared. Dr. B. A. Gould, in the "Uranometria, Argentina," has made some investigations into the form of the stellar universe, his results not being altogether in accordance with Proctor's; it is encouraging to see that others are now taking the subject up, though it does not appear that they have examined much into *details* of structure until within the last few months. The small amount of attention paid to the subject cannot arise from any lack of inherent interest it possesses, for it is one of the most important and mysterious in the whole range of astronomy; but it may be from an idea that observational astronomy would be unremunerative in this direction. But is this likely to be the case? Any theories that may be formed must be based on the knowledge of facts; and in one department of the subject in particular, namely, stellar distribution, Proctor has pointed out that much can be done towards increasing that knowledge. The application of photography to the stars, and further observations of their motions in the line of sight and across it, will accumulate much material for the confirmation or refutation of existent theories; but the present paper is written specially with a view of pointing out a few facts which have been gleaned by direct observation of one particular area of the sky. Any theory that may be advanced will have to account for these and similar facts that may be corroborated or accumulated by other observers. More persons are likely to pursue investigations of this kind when they realize that they will thereby be brought into acquaintance with scenes than which none are

more glorious, nor do any in the whole range of nature show the greatness of God more. And our admiration of His marvellous handiwork must be increased, even should the result be to diminish our ideas of the extent of the visible universe; and the substitution of facts for fancies can only be gain.

One of the most striking of the unexplained features of the structure of the universe is the *parallel arrangement;* sometimes simply of pairs of stars, at others of longer lines, or of broader bands of numerous stars, or of irresolvable nebulous wisps. This parallelism gives one the impression that the stars and wisps so arranged are physically connected, and the reality of this impression is a fair subject of enquiry. A very conspicuous instance of parallelism visible to the naked eye is in the region of the sky from Castor to ξ Ursæ Majoris, where we have the ten brightest stars arranged in five pairs, of which three are approximately parallel, and the other two do not deviate greatly from their direction, viz., Castor and Pollux, 38 and α Lyicis, ι and κ Ursæ Majoris λ and μ, and ν and ξ. This parallelism may even be traced, though less distinctly, over a much wider extent, including γ and δ Cancri, ζ and γ Leonis, η and α, δ and θ, ι and σ, 93 and β. But if we look at Proctor's map of the proper motions of the stars in "The Universe" (at end of volume) we find that there is no common proper motion among these stars, nor even in the two stars of each pair; the idea of physical connection seems therefore negatived, for if the two stars of the pairs are moving in different directions, whether one be revolving round the other or not, it is clear that in time the parallelism will be destroyed, unless the motion in all the pairs is similar—which is not the case. Nevertheless the conclusion is irresistible that in many cases such arrangement must be indicative of actual association.

For examination into details of structure the portion of the Milky Way between α Orionis and μ Geminorum was selected, and observed for the configurations of the stars, wisps, etc., contained in it, partly with a 4¼-inch refractor, but chiefly with a binocular field-glass of 2.05 inches aperture and power about 3.8; nearly all the observations having been made at Sunderland (England) during the last eight years.

The nebulous wisps alluded to are that faint and diffused luminosity which, when viewed with increasingly high powers is sometimes resolved into stars, sometimes remains partially or wholly unresolved, and sometimes disappears altogether. With the naked eye the Milky Way has an appearance of resolvability, as if it was composed of stars which would be separately visible with a telescope; but though the telescope does to a great extent resolve it, whatever magnifying power is used there is visible an abundance of irresolvable nebulosity which does not give any suspicion of being composed of stars; and in all parts of the sky fainter patches of it may be seen. There are three conceivable causes of the appearance of such nebulosity: it may consist of luminous gas or dust which no magnifying can resolve; or of faint stars too close together to be resolved with the power employed; or may, perhaps, be only a subjective appearance—for, when resolved, the nebulosity in some cases shows very small and densely packed stars, but in others widely scattered stars not much too faint to be individually visible with lower power—and in this latter case the writer suggests that the nebulous appearance may be caused by the glow round the stars being sufficiently extended to impress itself upon the eye, though the individual stars, being mere points, are invisible; while they are sufficiently near together for the glow from each to overlap that from its neighbors, so that an appearance of continuous nebulosity is produced. These nebulous wisps, etc., are wanting in catalogues of nebulæ, but since such catalogues include many resolvable clusters the questions arise, why should this be, and where does nebulosity end and a nebula begin?

Curves of stars have often been noted in the heavens; but in large portions of the observed area a parallel arrangement of the stars and an arrangement in straight lines, are by far the most striking feature; the irresolvable wisps (which are usually long and narrow) to a great extent falling in with the same arrangement as the stars. The portions of the area where the different parallelisms exist are in some cases very abruptly bounded, but in others cease gradually. Sometimes the parallelism reappears after a space where it is not perceived. In some cases the same stars

form lines belonging to more than one parallelism; it is possible that such instances are by mere chance, and that the star belongs really to only one. Of course, if one star belongs to two parallelisms, such is an indication that those two systems are in the same region of space, but it would be more natural to expect that the different parallelisms observed are in widely different regions, one being seen behind another. In Argelander's "Atlas des nördlichen gestiruten Himmels" the same lines are perceptible very often, but not in all cases; though several instances of parallel arrangement can be detected that escaped the use of the field-glass upon the sky, although that instrument appears to show stars down to nearly the same magnitude as are included in the Atlas. This difference in the results of the two examinations may be partly owing to the circumstance that often two or more stars close together may each be too small to be entered in the maps, but their united light may be impressed upon the eye; and, on the other hand, that the appearance of a line may be destroyed by the addition of somewhat fainter surrounding stars.

There is, besides the parallelisms, a most wonderful case of *radiation of stars and wisps* in a fan-shaped group, 68 Orionis being approximately the centre. The only counterparts to this which the writer has seen are the two following: On a far larger scale there is a radition, visible to the naked eye, from near the Pole star, to the Milky Way in the semicircle from ϵ Ursæ Minoris to β Camelopardi. This consists of stars and wisps. 2. A recent examination of Professor Barnard's photograph of the region around 11 Messier (in Aquila) shows lines of stars and dark lanes forming a not well-marked radiation, but, with little exception, it only subtends an angle of 50° or 60° from the point whence it radiates (in R. A. $18^h\ 50^m8$, Dec. —$9^\circ.9'$, for 1880). These two radiations are so much less marked than that from 68 Orionis, that it is quite doubtful whether they are more than an accidental appearance caused by a combination of adjacent parallel systems; but it seems highly improbable that such an explanation can be given to the radiation form 68 Orionis. If on further examination of the sky other examples are found, it may be possible to establish the radiated form as one of the recognized systems in the structure of the heavens.

From an investigation into the position-angles of the various systems of lines and wisps, it is apparent that they are grouped more numerously in certain directions than in others; the principal directions being nearly parallel with the galactic equator, or axis of the Milky Way. There is a marked deficiency of position-angles about at right-angles to the galactic equator; it is, perhaps, only a coincidence that this latter remark applies not only to the wisps and streams of stars in the area generally, but also to the lines in the great cluster in Gemini (35 Messier), which was examined with a 4¼-inch refractor, as well as in the MM. Henry's photograph of that object; the lines in the other clusters in the area, which were examined with the telescope, favor no particular direction.

It is manifest that so extensive an arrangement of stars in parallel lines cannot be the result of chance, and it is probable that those parallel to one another are in the same region of space. It therefore follows that the majority of the brighter stars in extensive tracts of the area we have been considering are really near one another. The only hypothesis that would not lead to such a conclusion is to suppose that there is a general tendency of all the stars in the sidereal universe to be grouped in parallel planes, in the same way as there is a tendency of the secondary systems in the solar system to be so. If this tendency existed, we should expect these planes to be parallel to the axis of the Milky Way; and we find the most prevalent direction of the lines in the area under consideration is nearly this. But this will not explain why there should be other systems of parallel lines. Then, as the irresolvable nebulosity lies so often in the same direction as the lines of stars, it must really be among them; and whether it contains any true nebulous matter or not, at least stars varying very greatly in magnitude must be associated together, so that these observations agree with Sir J. Herschel's on the Nubecula Major, and with Proctor's and Herbert Spencer's theories.

The bearing of this on the question of relative parallax is obvious and important; for if the conclusions arrived at are sound (without impugning the fact that difference of proper motion is often an indication of want of connection between stars), it would appear that if we take at random *any two stars* lying near together—say within a quarter of a degree

of each other—in the area of the sky that has been examined if not elsewhere, the chances are *much greater* that they are really near together than that they are far apart. *When two stars in the same neighborhood are found to have no appreciable relative parallax, this is not the slightest evidence of their remoteness from the earth,* it being just as likely the absence of relative parallax is owing to their proximity to one another.

The details of the before mentioned observations are scarcely suitable for, and would take up too much space in, the SIDEREAL MESSENGER; they have been tabulated and are to be printed separately, together with maps and diagrams, for distribution to those interested in the subject, and there will be much pleasure in forwarding copies to those who address the writer to this effect.

Sunderland, England, July 7, 1890.

TABLE OF STELLAR PARALLAXES.

In the February number of *Knowledge* will be found a very useful article by Herbert Sadler under the title, "List of Stellar Parallaxes." In that list is given the ordinary designation of the star, the approximate places for 1890, the magnitude roughly to the nearest half, in the photometric scale, the name of the observer or publisher of the determinations; the date, if marked with an asterisk the date of publication; the method of observation, the aperture of the instrument employed; the reference to the place of publication, and the actual parallax and probable error as determined by the observer. It may be useful to remark that the distance in light-years can be found by the use of the formula $\frac{3.2588}{P''}$, which cosresponds to a parallax of 8″.80, P being the parallax of any star under consideration. If the parallax be 8″.848, the formula then would be $\frac{3.24110}{P''}$.

By a recent letter from Mr. Sadler we received some corrections to the data as given in the article in *Knowledge*, which we have applied as he kindly suggested. We also take the liberty of putting the principal part of this interesting matter in tabular form, thinking that the respective data may be in a little more convenient form for reference and comparison. We have used great care to get all the matter correct as represented in the original article.—EDITOR.

Star.	Parallax and Probable Error	Kind.	Astronomer.	Instrument.	Reference.
	″ ″				
β Cassiopeiæ	+ 0.162 ± 0.051	R	Pritchard	Phot. Plates	M. N. vol. XLIX. No. 1.
" "	+ 0.154 ± 0.035	R	"	" "	Oxford Univ Observ Part III 1887–88.
34 Groombridge	+ 0.307 ± 0.0376	A	Auwers	Filar M.	Berlin Academy 1867.
ζ Tucanae	+ 0.06 ± 0.02	R	Elkin	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
α Cassiopeiæ	+ 0.071 ± 0.040	R	Pritchard	Phot. Plates	M. N. vol XLIX No.
" "	+ 0.036 ± 0.023	R	"	" "	Oxford Univ Observ. Part III 1887–88.
η Cassiopeiæ	+ 0.154 ± 0.045	R	O. Struve	Filar M.	Bulletin physico math. Ac. Sc. Petersbourg, vol. XIV, p. 231.
" "	+ 0.3743 ± 0.0723	R	Schweizer-Socoloff	" "	Annals of Obs. of Moscow vol. VIII, Part II, p. 89.
γ Cassiopeiæ	− 0.014 ± 0.047	R	Pritchard	Phot. Plates	M. N. vol. XLIX, No. 1.
" "	+ 0.007 ± 0.042	R	"	" "	" " " "
" "	− 0.025 ± 0.031	R	"	" "	Oxford Univ. Observ. Part III 1887–88.
" "	+ 0.050 ± 0.036	R	"	" "	" " " "
μ Cassiopeiæ	− 0.12 ± 0.29	R	Bessel	Transit Inst.	Bessel Abhandlungen vol II, p. 216.
" "	+ 0.342 ± 0.052	R	O. Struve	Filar M.	Bulletin physico-math. Ac. Sc. Petersbourg, vol. XIV, p. 231.
" "	− 0.1432 ± 0.1140	R	Schweizer-Socoloff	" "	Annals of Obs. of Moscow vol. VIII. Part II, p. 89.
" "	+ 0.036 ± 0.025	R	Pritchard	Photo. Plates	M. N. vol. XLIX, No. 1.
Nova Andromedæ	− 0.32 ± 1.12	R	Franz	Heliometer	A. N. No 2816 (very doubtful).
" "	− 0.11 ± 0.14	R	"	"	" " "
" "	Insensible.	R	Hall	Filar M	
α Ursæ Minoris	+ 1.31	A	Piazza-Cacciatore	Transit Inst.	Præcipuarum Stellarum inerantium, Pos. Med.
" "	+ 0.24	A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 38.
" "	+ 0.144 ± 0.032	A	Von Lindenau		B. J. 1820.
" "	+ 0.60 ± 0.12	A	Brioschi	Vert. Circle	Recueil de Mem. des Astr de Pulkova, vol. I, p. 175.
" "	+ 0.075 ± 0.034	A	W. Struve	Transit Inst.	" " " "

Star.	Parallax and Probable Error.	Kind.	Astronomer.	Instrument.	Reference.
	″ ″				
α Ursæ Minoris	+ 0.172 ± 0.027	A	W. Struve and Preuss	Mer. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 65.
" "	+ 0.147 ± 0.030	A	" " "	" "	" " " "
" "	+ 0.067 ± 0.012	A	C. A. F. Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.068 ± 0.012	A	Glasenapp	Rediscussion of Peters Results.	(Refraktsionnya oklony.)
" "	+ 0.015 ± 0.015	A	L. De Ball	Mer. Circle	A. N. No. 2667.
" "	+ 0.073 ± 0.014	R	Pritchard	Phot. Plate	M. N. vol. XLIX, No. 1.
" "	+ 0.079	R	"	" "	Oxford Univ. Obs. Part III.
e (Lac. 1060) Eridani	+ 0.14 ± 0.02	R	Elkin	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
P iii 242	+ 0.045 ± 0.070	R	Sir R. Ball	Filar M.	Dunsink Observations, Part V, p. 226.
o^2. (40) Eridani	+ 0.166 ± 0.018	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
" "	+ 0.223 ± 0.020	R	Hall	Filar M.	Wash. Observations, for 1883 App. II.
α Tauri	+ 1.5	A	Piazzi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 30.
" "	+ 0.516 ± 0.057	R	O. Struve-Shdanow	Filar M.	M. N. vol. XLIV, p. 237.
" "	+ 0.102 ± 0.0296	R	Hall	" "	Gould's Astr. Journal, No. 156.
" "	+ 0.116 ± 0.029	R	Elkin	Heliometer	Report of Yale Univ. Observ.
α Aurigæ	+ 0.046 ± 0.200	A	Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.305 ± 0.043	R	O. Struve	Filar M.	Bulletin physico-math. Ac. Sc. Petersbourg, vol. XIV, p. 234.
" "	− 0.087 ± 0.130		"	" "	From measures of distance.
" "	+ 0.362 ± 0.048		"	" "	" " " pos. angles.
" "	+ 0.522 ± 0.181	A	Glasenapp	Rediscussion of Peters' Result	Refraktsionnya oklony.
" "	+ 0.107 ± 0.047	R	Elkin	Heliometer	Report of Yale Univ. Observ.
α Orionis	− 0.009 ± 0.049	R	Elkin	Heliometer	Report of Yale Observatory.
α Argus (Canopus)	+ 0.03 ± 0.030	R	Elkin	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
ψ^5 Aurigæ (Comes)	+ 0.111 ± 0.034	R	Schur	Filar M.	A. N. No. 2723.

						p. 31.
" " "	+ 0.23	± 0.10	A	Henderson and Maclear	Mural Circle	Mem. R. A. S. vol. XI, p. 248.
α Canis Maj.	+ 0.34	± 0.11		Henderson		
" " "	+ 0.16	± 0.09		Maclear		
" " "	+ 0.15	± 0.09	A	Peters-Maclear	Rediscussion of Maclear's Res.	Recueil de Mem. des Astr. de Pulkova, p. 64.
" " "	+ 0.193	± 0.087	A	Gylden-Maclear	Rediscussion of Maclear's Res.	Bulletin Ac. Sc. Petersbourgh, vol. VII. p. 370.
" " "	+ 0.43	± 0.099	A	Belopolsky-Wagner	Mr. Circle	A. N. No. 2888.
" " "	+ 0.27	± 0.10	A	Abbe-Maclear	Rediscussion of Maclear's Res.	M. N. vol. XXVIII, p. 6.
" " "	+ 0.370	± 0.009	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
" " "	+ 0.407	± 0.018	R	Elkin	"	" " " " "
51-Hev. Cephei	+ 0.027	± 0.019	A	L. De Ball	Discussions of Wagner's Obs.	A. N. No. 2667.
α Geminorun	+ 0.198	± 0.062	R	Johnson	Heliometer	Radcliffe Observations, vol. XVI, p. 20.
α Canis Minoris	± 3.		A	Piazzi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 31.
" " "	+ 0.240*	± 0.029	R	Auwers	Heliometer	A. N. No. 1415. * mean
" " "	+ 0.299	± 0.038	R	Wagner	Mer. Circle	Mem. of Acad. of St. Petersburg, Series 7, vol. XXXI, Part II.
" " "	+ 0.266	± 0.047	R	Elkin	Heliometer	Report of Yale Coll. Observatory.
β Geminorum	+ 0.068	± 0.047	R	Elkin	Heliometer	" " " " "
ι Ursæ Majoris	+ 0.133	± 0.106	A	Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, p. 136.
" " "	+ 0.127	± 0.106	A	Glasenapp	Redis. of Peters' Results	Refraktsionnya oklony.
10 Ursæ Maj.	+ 0.20	± 0.11	A	Belopolsky-Wagner	Mer. Circle	A. N. No. 2888.
Struve 1321 prec.	+ 0.087	± 0.021	R	Kapteyn	" "	" " 2935.
θ Ursæ Maj.	+ 0.046	± 0.029		Kapteyn	" "	" " "
Lal. 19022	+ 0.072	± 0.020		Kapteyn	" "	" " "
30 Leon. Min.	+ 0.071	± 0.028		Kapteyn	" "	" " "
α Leonis	+ 0.093	± 0.048	R	Elkin	Heliometer	Reportof Yale Coll. Observatory.
Groombridge 1618	+ 0.334	± 0.036	R	Sir R. Ball	Filar M.	Dunsink Observations, Part V, p. 197.

Star.	Parallax and Probable Error.	Kind.	Astronomer.	Instrument.	Reference.
	″ ″				
Groombridge 1618	+ 0.177 ± 0.023	R	Kapteyn	Filar M.	Dunsink Observations, Part V, p. 197.
" 1646	+ 0.109 ± 0.025	R	Kapteyn	Mer. Circle	A. N. No. 2935.
" 1657	+ 0.025 ± 0.028	R	Kapteyn	" "	" " "
Lal. 20670	− 0.006 ± 0.028	R	Kapteyn	" "	" " "
β Ursæ Maj.	+0.0102 to +0.0114	A	Klinkerfues	Displ. of lines of Spec. by Huggins	Gesells 1873, No. XIII.
α Ursæ Maj.	+ 1.22 ± 0.44	A	Brioschi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 175.
Lal. 21185	+ 0.511 ± 0.015	R	Winnecke	Heliometer	A. N. No. 1147.
" "	+ 0.501 ± 0.011	R	Winnecke	"	Publ. der Ast. Gesells, No. XI.
" "	+ 0.434 ± 0.028	R	Kapteyn	"	" " " " "
Lal. 21258	+ 0.262 ± 0.011	R	Auwers	Heliometer	M. N. vol. XXIII, p. 75.
	[+ 0.271 ± 0.11]	A			
" "	+ 0.260 ± 0.020	R	Krueger	Heliometer	Acta Fennicæ Soc. Scientiarum, vol. VII, p. 390.
" "	+ 0.167 ± 0.027	R	Kapteyn	"	" " " " "
Struve 1516	+ 0.28 ± 0.04	R	Berberich	Filar M.	A. N. No. 2624.
" "	+ 0.199 ± 0.050	R	Winnecke	" "	" " "
" "	+ 0.104 ± 0.008	R	L. De Ball	Filar M.	Mem. Acad. de Belgique, vol. XLIX.
Œltz. Arg. 11677	+ 0.272 ± 0.038	R	Geelmuyden	Filar M.	A. N. No. 2287. Also No. 2666.
Struve 1561 seq.	+ 0.047 ± 0.026	R	Kapteyn	Mer. Circle	" " 2935.
Groombridge 1822	+ 0.018 ± 0.031	R	Kapteyn	" "	" " "
Groombridge 1830	+ 0.226 ± 0.141	A	Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 1.058	R	Faye	Dif. of R. A.*	Comptes Rendus, vol. XXV, p. 141.
	+ 1.085 ± 0.065		"	" "	" " " XXIII, p. 1078.
" "	+ 0.182 ± 0.018	R	Wichmann and Schluter	Heliometer	A. N. No. 610.
" "	+ 0.034 ± 0.031	R	O. Struve	Filar M.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 293.
" "	+ 0.08 ± 0.027	R	Wichmann	Redis. of Schlurs & his own Obs.	A. N. No. 844.

* With a neighboring Star obtained with reflector of 13-inch aperture.

Groombridge 1830	+ 0.135	± 0.013†				
" "	+ 0.72	± 0.043‡				
" "	+ 0.141	± 0.013	R	Peters	(Redis. of obs. of Schluter and Wichman.)	A. N. No. 866.
" "	+ 0.148	± 0.013	[A]	Peters		
" "	+ 0.114	± 0.019	R	Wichmann	Quot. by Auwers	Monat der Akad. zu Berlin 1874, p. 591.
" "	+ 0.166	± 0.018	R	Schluter	" " "	" " " " " " "
" "	+ 0.033	± 0.028	R	Johnson	Heliometer	Radcliffe Observations vol. XIV, p. 48.
" "	+ 0.023	± 0.033	R	Johnson	Redis. by Auwers	*Loc. cit.*
" "	+ 0.089	± 0.017	R	Brunnow	Filar M.	Dunsink Observations, Part II, p. 23.
" "	+ 0.262	± 0.141	A	Glasenapp	Redis. of Peters' Results.	Refraktsionnya oklony.
" "	+ 0.161	± 0.029		Kapteyn	Mer. Circle	A. N. No. 2935.
γ Ursæ Maj.	+ 0.39	•	A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I. p. 40.
"	+ 0.0164 to + 0.0183		A	Klinkerfues	Disp. of lines of spec. by Huggins	Gesells, etc., der Gottingen, 1873, No. 13, p. 357.
Lal. 22632	− 0.039	± 0.038	R	Kapteyn	Merid. Circle.	A. N. No. 2935.
Lal. 22810	+ 0.067	± 0.030	R	Kapteyn	" "	" " "
δ Ursæ Maj.	+ 0.0244 to + 0.0271		A	Klinkerfues	Displ. of lines of spec. by Huggins	Gesells, etc., der Gottingen, 1873, No. 13, p. 357.
ε Urs. Maj.	+ 0.33		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" " "	+ 0.41	± 0.35	A	Brioschi	" "	" " " "
" " "	+ 0.0301	± 0.0334		Klinkerfues	Disp. of lines, spec. by Huggins	Gesells, etc., der Gottingen No. 13, p. 357.
ζ Urs. Maj.	+ 0.28		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" " "	+ 0.429 to + 0.0477		A	Klinkerfues	Disp. of lines of spec. by Huggins	Gesells, etc., der Gottingen No. 13, p. 357.
α Virginis	− 0.42	± 0.33	A	Brioschi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova. vol. I, p. 175.
η Ursae Maj.	+ 0.095		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
β Centauri	+ 0.470	± 0.044	A	Maclear	Mural Circle	Mem. R. A. S. vol. XXI, p. 152.
" "	+ 0.213	± 0.069	A	Mœsta	Transit Circle	A. N. No. 1688.

† Another determination. ‡ By another method.

Star.	Parallax and Probable Error.	Kind.	Astronomer.	Instrument.	Reference.
	″ ″				
β Centauri	+ 0.173 ± 0.07	A	Mœsta	A fresh determination	A. N. No. 2349.
" "	− 0.018 ± 0.019	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
α Bootis	+ 1.1 ± 0.15	A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 0.61	A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 0.652	A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	+ 0.127 ± 0.074	A	Peters	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.169 ± 0.044	R	Johnson	Heliometer	Radcliffe Observations, vol. XVI.
" "	+ 0.210 ± 0.073	A	Glasenapp	Redis. of Peters' results	S. Glasenapp. Refraktsionnya oklony.
" "	+ 0.018 ± 0.022	R	Elkin	Heliometer	Report of Yale College Observatory.
α Centauri	+ 1.14 ± 0.11	A	Henderson	Mural Circle	Mem. R. A. S. vol. XI, p. 68.
" "	+ 0.913 ± 0.064	A	Henderson-Maclear	2 Mural Circles	" " " XII, p. 370.
" "	+ 0.976 ± 0.064 with other corrections + 0.49	A	Peters-Maclear	Redis. Maclear's results	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 63.
" "	+ 0.880 ± 0.068	A	Mœsta	Transit Circle	A. N. No. 1688.
" "	+ 0.521 ± 0.066	A	Mœsta	A fresh determination	" " 2349.
" "	+ 0.512 ± 0.080	A	Elkin-Maclear	Redis. Maclear's results	Uber die Parallax von α Centauri.
" "	+ 0.76 ± 0.013	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
" "	+ 0.676 ± 0.027	R	Elkin	"	Loc. cit.
β Ursæ Min.	− 0.38 ± 0.37	A	Brioschi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, p. 175.
η Herculis	+ 0.40 ± 0.072	A	Belopolsky-Wagner	Transit Circle	A. N. No. 2888.
α Herculis	+ 0.586	R	Bessel	Reflector	Briefwechsel mit Olbers, vol. I, p. 47.

α Herculis	+ 0.061	± 0.008	R	Jacob	Filar M.	Madras Observations, vol. VII. Appendix, p. 20.
π Herculis	+ 0.11	± 0.063	A	Belopolsky-Wagner	Merid. Circle	A. N. No. 2888.
α Ophiuchi	+ 1.57		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova.
ν Draconis	+ 0.32 preceding star	± 0.076	A	Belopolsky-Wagner	Merid. Circle	A. N. No. 2888.
	+ 0.28 following star	± 0.088		" "	" "	" " "
17,414 Œltz Arg.	+ 0.247	± 0.0211	R	Krueger	Heliometer	Acta Fennicæ Soc. Scientiarum, vol. VII, p. 383.
" " "	+ 0.1914	± 0.030	R	Schweizer-Socoloff	Filar M.	Annales de l'Observatoire de Moscow, vol. VIII, Part II, p. 90.
γ Draconis	− 0.08		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 0.0704		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	+ 0.05		A	Pond	Mural Circle	Ph. Trans. vol. CVII, p. 170.
" "	− 0.242		A	Main	Reflex Zenith Tube	Mem. R. A. S. vol. XXIX, p. 189.
" "	− 0.131	± 0.041	A	Downing	Reflex Zenith Tube	M. N. vol. XLII, p. 344.
Nebula Herschel	+ 0.009	± 0.041	R	Bredichin	Filar M.	Annales de l'Observatoire de Moscow, vol. III, Part IV.
" "	+ 0.047	± 0.030	R	Brunnow	" "	Dunsink Observations, Part III, p. 6.
70 Ophiuchi	+ 0.169	± 0.010	R	Krueger	Heliometer	A. N. No. 1212.
	+ 0.162	± 0.007	R	"	"	" " 1403.
δ Ursæ Min.	+ 0.203	± 0.037	A	W. Struve	Transit	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 55.
" " "	+ 0.034	± 0.017	A	L. De Ball	Disc. Wagner's Obs. with mer. cir. 1861-72	A. N. No. 2669.
α Lyræ	+ 3.9		A	Calandrelli	Sector	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 33.
" "	+ 1.26		A	Brinkley	Vert. Cir.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 38.

Star.	Parallax and Probable Error.		Kind.	Astronomer.	Instrument.	Reference.
	"	"				
α Lyræ	+ 0.66	± 0.08	A	Brinkley	Vert. Cir.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 1.21		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 1.138		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 41.
" "	+ 0.37	± 0.29	A	Brioschi	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 175.
" "	+ 0.007		A	Pond	Tran. mur. cir.	Ph. Trans. vol. CVII, p. 170.
" "	+ 0.224		A	Airy	Mural Circle	Mem. R. A. S. vol. X.
" "	− 0.092		A	"	" "	Loc. cit.
" "	+ 0.262	± 0.025	R	W. Struve	Filar M.	Additamentum in Mens. Micr.
α Lyræ	+ 0.103	± 0.053	A	Peters	Vert. Circ.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.147	± 0.009	R	O. Struve	Filar M.	Mem. Acad. St. Petersbourg, series VII, vol. I, p. 50.
" "	+ 0.137		A	"	" "	Mem. Acad. St. Petersbourg, series VII, vol. I, p. 50.
" "	+ 0.154	± 0.046	R	Johnson	Heliometer	Radcliffe Observations, vol. XVI, p. 30.
" "	+ 0.212	± 0.010	R	Brunnow	Filar M.	Dunsink Observations, Part I, p. 29.
" "	+ 0.131	± 0.033	R	"	" "	" " " II, p. 55.
" "	[+ 0.188	± 0.033]	R	"	" "	" " " II, p. 57.
" "	+ 0.134	± 0.006	R	Hall	" "	Washington Observations for 1883, Appendix II.
" "	+ 0.110	± 0.050	A	Glasenapp	Redis. of Peters' results	Refraktsionnya oklony.
" "	+ 0.034	± 0.045	R	Elkin	Heliometer	Report of Yale College Observatory.
Œltz Arg. 18609	+ 0.34	± 0.34	R	Lamp	Filar M.	A. N. No. 2676.
" " "	+ 0.353	± 0.014	R	"	" "	" " 2808.
Cygni 6 (Bode)	+ 0.482	± 0.054	R	Sir R. Ball	" "	Dunsink Observations, Part V, p. 238.
" "	− 0.021	± 0.008	R	Hall	" "	Washington Astr. Observations 1883, App. II, p. 42.

δ Aquilæ	+ 3.20		A	Brinkley	Vert. Cir.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
σ Draconis	+ 0.222	± 0.022	R	Brunnow	Filar M.	Dunsink Observations, Part I, p. 44.
" "	+ 0.262	± 0.20	R	"	" "	" " " II, p. 30.
γ Aquilæ	+ 2.19		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
α Aquilæ	+ 2.53		A	Brinkley	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 1.57		A	"		Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 1.731		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	+ 0.978		A	Taylor	Mural Circle	Madras Observations, vol. II, p. 132.
" "	+ 0.181	± 0.094		W. Struve(?)	Quoted by Elkin	Report of Yale University Observatory.
" "	+ 0.199	± 0.047	R	Elkin	Heliometer	" " " " "
β Aquilæ	+ 2.36		A	Brinkley	Vert. Circle.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
α Cygni	+ 0.78		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 0.33		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 0.50		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	− 0.082	± 0.043	A	Peters	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	− 0.059	± 0.043	A	Glasenapp	Redis. of Peters' results	Refraktsionnya oklony.
" "	− 0.042	± 0.047	A	Elkin	Heliometer	Report of Yale Observatory.
61 Cygni	+ 0.55		A	Arago et Mathieu	Repeating cir.	Annaire du Bureau des Longitudes 1834, p. 281.
" "	+ 0.47	± 0.51	A	Lindenau reduced anew by Peters	Transit	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 48.
" "	− 0.88	± 0.19	A	Bessel	Transit	Peters loc. cit.
" "	+ 0.3483	± 0.009	R	Bessel & Schluter	Heliometer	Peters op. cit. p. 60.
	[+ 0.3136	± 0.014]		Bessel		
" "	+ 0.349	± 0.080	A	Peters	Vert. Circle	Peters op. cit. p. 136.

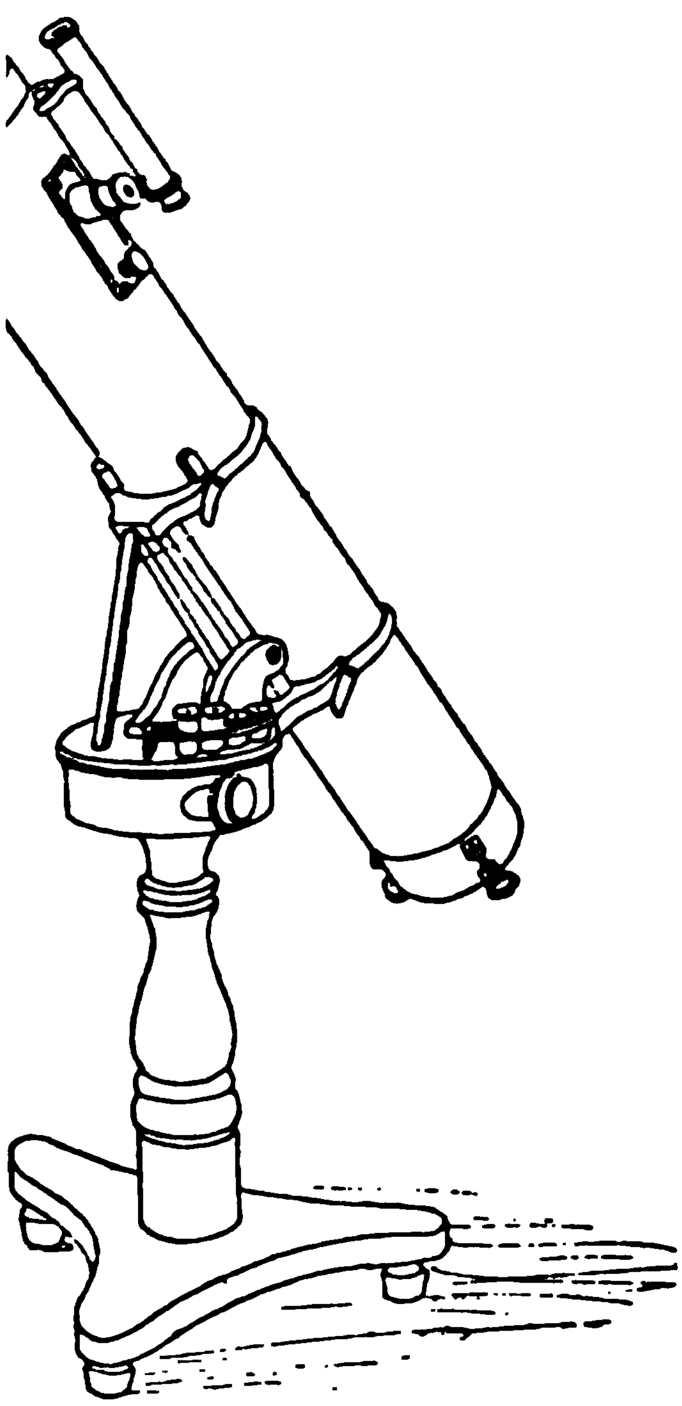
Star.	Parallax and Probable Error.	Kind.	Astronomer.	Instrument.	Reference.
" "	+ 0.402 ± 0.016	R	Johnson	Heliometer	Radcliffe Observations, vol. XIV, p. 39.
61 Cygni	+ 0.506 ± 0.028	R	O. Struve	Filar M.	St. Petersbourg Acad. Mem., vol. VII, p. 51.
" "	+ 0.360 ± 0.012	R	C. A. F. Peters	Redis. of Bessel's and Schluter's results	A. N. No. 866.
" "	+ 0.566 ± 0.016	R	Auwers	Heliometer	M. N. vol. XXIII, p. 75.
" "	+ 0.525 ± 0.093	A	Belopolsky-Wagner	Merid. Circle	A. N. No. 2888.
" "	+ 0.4330 ± 0.2091	R	Schweizer-Socoloff	Filar M.	l'Observatoire de Moscow, vol. VIII, Part II, p. 90.
" "	+ 0.465 ± 0.049	R	Sir R. Ball	" "	Dunsink Observations, Part III, p. 27.
" "	+ 0.468 ± 0.032	R	" " "	" "	". " " V, p. 166.
" "	+ 0.430 ± 0.049	A	Glasenapp	Redis. of Peters' Results	Refraktsionnya oklony.
" "	+ 0.270 ± 0.010	R	Hall	Filar M.	Washington Observations 1883, App. II.
" "	+ 0.432 ± 0.437	R	Pritchard	Photo. with Reflector	M. N. vol. XLVII, p. 445.
α Cephei	+ 0.061	R	"	Photo. with Reflector	Oxford University Observations, Part III.
ε Indi	+ 0.27 ± 0.02	R	Gill	Heliometer	Mem. R. A. S., vol. XLVIII, Part I.
" "	+ 0.12 ± 0.19	R	Elkin	"	Report of Yale Observatory.
Lac 9352	+ 0.285 ± 0.02	R	Gill	"	Mem. R. A. S., vol. XLVIII, Part I.
Bradley 3077	+ 0.069 ± 0.27	R	Brunnow	Filar M.	Dunsink Observations, Part II, p. 49.
" "	+ 0.205 ± 0.079	A	Backlund-Wagner	Transit Circle	Copernicus vol. II, p. 202.
" "	+ 0.283 ± 0.047	R	Gylden	Filar M.	Stockholm Akad. Ofversigt, 1882.
85 Pegasi.	+ 0.054 ± 0.019	R	Brunnow	" "	Dunsink Observations, Part II, p. 42.

A TELESCOPE MIRROR IS GROUND, POLISHED AND FIGURED.

GEORGE S. JONES.

: MESSENGER.

"silver-on-glass" reflecting telescope has of late years igh in favor with amateur astronomers, particularly gland. Its mirrors of pure silver—the glass being the mould or form on which the mirrors proper rest —reflect nearly as large a percentage of the light as finds its way through the four surfaces of an object glass; it is entirely free from the defect of "chromatism," which cannot be said of the best "achromatic," and with careful workmanship it may be corrected perfectly for spherical aberration, — points which render it for most purposes a formidable rival of the more common refractor. No more clean and clear-cut views of a celestial object can be had than may be obtained with a good reflecting telescope.



But aside from the intrinsic merits of the reflector as now made, that which recommends it especially to :eurs, who are apt to be persons of limited means, is its parativelv small cost, or to look at this feature from a ent point of view, the simplicity of its construction, h renders it quite practicable for one who has a fair ınt of mechanical skill to make his own telescope. A or is a far less complicated piece of work than an achroc object glass. It has but one surface to grind and h, whereas an object glass has four, the curvatures of

all of which must be made to conform very exactly to the requirements of a previously prepared mathematical formula. Furthermore, since the surface only is used, the light not passing through the glass, it is not necessary to use for it expensive optical glass, but only glass that is of a homogeneous density, and is fairly free from air bubbles, will answer the purpose. When the one surface has been polished and brought to the right figure, the work is done. The silvering of the glass is a very simple matter; and the cost of silvering is a mere trifle.

The description which we shall give of the process of making one of these glass mirrors is based upon the writer's personal experience in an amateur way. It is hoped that it will not merely serve to satisfy a curiosity as to how work of this kind is done, but that it may be of some service to others who may be disposed to try in this direction the cunning of their own hands. Complete success may not come with the first trial; but with perseverance it will come in the end, and it will be worth the cost of a few failures.

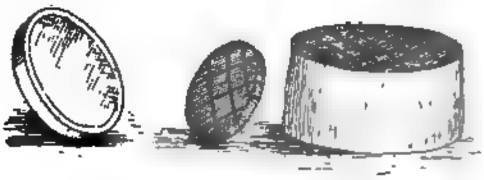
With the theory of the reflecting telescope the reader may be presumed to be acquainted. At any rate he can easily inform himself on this point from any work on optics. It is sufficient to say that the form of reflector now commonly used is the Newtonian, in which the image formed by the large concave mirror is thrown out at one side of the tube, near its upper end, by means of a small plane mirror or "flat," and in this position is magnified with an eye-piece of the same kind as is used with a refracting telescope.

To describe the process of making this concave mirror, we cannot do better, perhaps, than to take the reader directly into our workshop and give him the actual history of a 6¼-inch mirror, which he may see, in imagination, lying upon the table, only recently finished and still unsilvered. It may be well to say in advance, however, that in the more delicate parts of the work of making a mirror, particularly in the figuring or shaping of it, after the polishing is completed, different artists have employed different methods, and in some instances have left on record their want of success with the methods recommended by others. Our own experience has not been exceptional in this respect. The methods to be described below are simply those which, after many trials, have been found to yield the best results.

The disc for this mirror was of ordinary rough plate glass, 6¾ inches in diameter and about one inch in thickness. The grinding being the least difficult as well as the least interesting part of the work, may be disposed of in a few words. The rough disk was first ground with emery and water upon a flat plate of iron until its two faces were smooth and parallel; its edge was then trued by grinding in a lathe; specially adapted to this purpose, after which it was laid upon a table and its upper surface was hollowed out roughly to the required depth by vigorously scrubbing it with an iron tool fed with emery and water. The rough grinding done, the work was continued with a thick disc of cast iron, five inches in diameter, one face of which had been carefully turned in a lathe to the required convexity and afterwards grooved into squares of one inch. The curvature of the face of this tool, which was also to be the curvature of the mirror, had a radius of ten feet, it being designed that the mirror should have a focal length of five feet. As the grinding progressed emery of a finer and finer grade was used, the finishing touches being given with the very finest flour of emery obtainable by a process of elutriation, which need not be here described. In the fine grinding the greatest care is necessary to avoid scratching; but the reader can be spared the recital of such mishaps. It may be said here, parenthetically, that when two surfaces are ground together, the abrasion is caused by the rolling of the hard particles of emery between them and not by scraping, as upon a grindstone or an emery wheel. It is only when a too coarse particle of emery becomes lodged in some part of the tool that a scratch is produced, and it is to facilitate the escape of such particles that the grooves, before mentioned are made on its face.

The work of grinding is finally completed successfully, we will suppose. The surface of the glass is free both from scratches and from the nicks made in it by the coarse grinding; its curvature is perfectly spherical; it is as smooth to the touch as though it were already polished, and it will reflect the light of a gas jet at an angle of 45°; it is ready to be polished. The curvature of such a mirror, it may here be said is less than the reader may, perhaps, imagine. A "straight edge" laid across it is at the center no more than .04 of an inch above the surface.

The polishing is done with rouge, mixed with water, upon a tool of wood or iron, the surface of which is covered to the depth of an eighth of an inch, or more, with pitch. Like the grinding tool the polisher is cut into squares, in order to allow the pitch, which should be soft enough to yield gradually in the process of polishing, a chance to spread uniformly. The tool used with this mirror was a heavy circular block of wood, eight inches in diameter, experience indicating this as the proper size. If the polisher is too small, the polishing will proceed faster in the center of the mirror than at the border; if too large the reverse. With the polishing begins the really difficult work. To brighten



MIRROR. GRINDING TOOL. POLISHER.

the surface of the glass by scrubbing it backward and forward and round and round over the rouge-covered polisher is, indeed, easy enough, although a work of time, and with a little care the glass need not be scratched. But something more than a bright surface is required. The novice at this work will certainly spoil his first mirror; probably also his second and third. His chief misfortune will be that he will polish it into rings of different curvature. When he finishes his work, he will find that his mirror, if he is able to test it, has no regular figure; it is not spherical; it is not parabolic, it is not hyperbolic; it exhibits a combination of curves of different radii, and bright as it may be, it is, for the purpose for which it is designed, absolutely worthless. The only sure remedy in this case—it is hard, but it will save time in the end—is to put on the grinding tool again and take a fresh start. In time the learner will discover and correct the faults in his manipulation; but rules and directions given by another are of very little service.

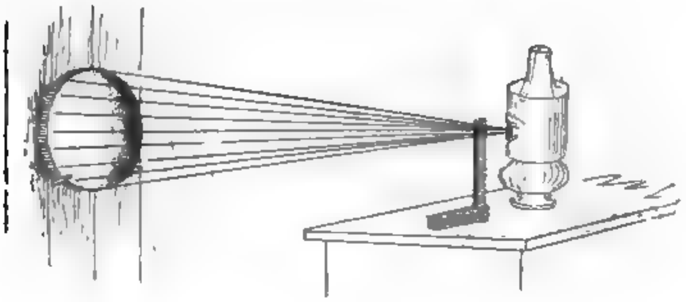
The mirror in question having been polished by one who had gone through the hard school of experience, came from the polisher in a satisfactory shape. Its figure was, how-

ever, by no means that desired, although it was one which could easily be corrected. The process of testing and correcting a mirror is, perhaps, that part of the work in which the reader will be the most interested; but it is hardly possible, without the aid of elaborate diagrams, to give a very clear idea of this process. Let us first see what figure is required. If a mirror of a perfectly spherical surface be made to reflect perfectly parallel rays of light, for example the rays of light coming from a star, those rays which strike near the center of the mirror will be so reflected as to come to a point or "focus" exactly half way between the center of curvature of the mirror and its surface; those which strike the mirror near its edge will be brought to a focus a little before they reach this central point, and the rays from other parts of the mirror will be focussed at points between these two extremes. The difference between the focus of the central and that of the outside rays of a spherical mirror is technically called its "aberration." In the case of a 6-inch mirror of five feet focal length, the aberration is a little less than .02 of an inch. This may seem a trifling matter, and, indeed, if we use an eye-piece of one or two inches in focal length, giving a low power, so slight a failure to focus exactly would not seriously mar the mirror's performance, but if we wish for a high power and use an eye-piece of no more than one-eighth or even one-quarter of an inch focus, it can easily be understood how an aberration even of one-fiftieth of an inch would render the image, thus highly magnified, blurred and indistinct in all its more minute details. A good "definition" with such a mirror would be an impossibility. The remedy is either to shorten the focus of the central rays by polishing out the central part of the mirror, giving it more curvature here, or to lengthen the focus of the outside rays by giving to the outer portion of the mirror less curvature. Upon the accuracy with which this correction of the figure is made will depend the value of the mirror. If the figure is perfectly corrected, all the rays of light from a distant luminous point will be brought to the same focus, and the image formed by an agregation of such points will be so sharply defined that it may be magnified to any desired extent, that is, until a limit is reached beyond which, owing to deficiency of light, magnification ceases to be of ad-

vantage. Such a figure, it is easy to show geometrically, is a section of a paraboloid. How exceedingly delicate must be the work of producing it, may be judged from a calculation, made by Sir William Herschel, that to give to a four-foot mirror whose curvature is perfectly spherical a parabolic curvature, it is necessary to polish off from the part near the circumference a layer of metal less than one twenty-thousandth part of an inch in thickness. With the most delicate measuring instruments it would, of course, be impossible to detect so slight a departure as this from the true spherical figure. This can be done only by means of optical tests, and of these there are several, the most beautiful of which, discovered by Foucault, is about to be described. By the Foucault method we are enabled to determine the exact figure of a mirror by simple inspection, all the features of its surface being exhibited in a highly exaggerated form, and it may be remarked here that had Herschel possessed this test, he would, no doubt, have been spared many a weary hour of labor, while working almost blindly to improve a mirror without knowing exactly where its defect lay.

The method of testing is this: The mirror is suspended against the wall of a darkened room, at a convenient height from the floor, and at the center of curvature—in the present case at a distance of ten feet from the mirror—is placed a lamp provided with a metal screen, in which, directly opposite the flame, are punched two or three holes of different sizes. The largest of these is a mere pin-hole; the smallest, the most minute which can be made with the point of a fine cambric needle. The light radiating from these holes, falling perpendicularly upon the mirror, is reflected back and forms optical images of them, which, by properly setting the mirror, may be brought a few inches to one side of the lamp, so that they can be magnified and examined with a lens or, better still, with a telescope eye-piece. If the mirror has a perfectly spherical curvature, these images will be seen sharply defined, as in a microscope, with no tails of light nor diffused illumination about them, all their ragged edges being distinctly visible. This is a good test to begin with and it will give us some idea of the condition of our mirror; but it is far less delicate than the Foucault test referred to above, which is now universally employed. To apply this

test, remove the eye-piece and place the eye eight or ten inches back from the focus. The holes will be seen as luminous spots, apparently on the mirror but in reality ten feet in front of it. Selecting the largest of them, keep it steadily in sight, while the eye is slowly moved towards the focus. The bright spot becomes blurred; it enlarges to a luminous blotch on the mirror, and finally, when the eye has been brought to within an inch or less of the focus, the whole surface of the mirror is seen suffused well with light. Now, keeping the eye steadily in this place, take a straight-edge in the right hand—a narrow strip of thin metal will answer for this purpose—and pass it slowly across the cone of light



THE TEST.

near the focus and between it and the mirror. As the straight edge, held perpendicularly, enters the cone of rays it is seen projected as a dark shadow on the right hand side of the illuminated mirror. Repeat the act, bringing the straight edge a little nearer to the focus. When it has been brought to a certain point, the shadow on the mirror ceases to be uniformly dark, as at first, but its inner edge becomes shaded and curved in such a manner as to give to the mirror the appearance of being a luminous ball, a foot or so in diameter. The illusion is perfect. As the straight edge is brought nearer and nearer to the focus, this deceptive appearance of convexity becomes less and less marked and finally, when it is passed across exactly at the focus, instead of a shadow making its appearance from one side, the illumination of the mirror gradually fades over all parts of its surface alike and the impression given is that it is perfectly *flat*. Continue the operation, passing the straight edge be-

tween the focus and the eye. The shadow now enters from the left side and the mirror appears to be concave. These are the appearances successively presented when the mirror is perfectly spherical. If it has some other figure,—if it is parabolic, or hyperbolic, or is full of rings, or has some other defect of curvature, a practiced eye will detect its faults at once by the appearance presented by the shaded surface. If, for example, it is parabolic, the figure desired, when the straight edge is inserted into the focus, the surface of the mirror, instead of appearing to be flat, will appear very slightly concave in the central part and convex near its circumference. If it is hyperbolic, that is more than parabolic, a similar appearance is presented but more exaggerated. In practice our mirrors have always come from the polisher with a hyperbolic figure. To bring them to a parabolic figure, it has been necessary to polish out the surface between the centre and the circumference. After many experiments we have found the best and safest polisher for this purpose to be the finger. The process requires the greatest care and the work must be examined every few minutes by the means above described. How delicate an operation it is can be imagined, when it is said that the warmth of the hand, held above the mirror in polishing, expands its upper surface to such an extent as very sensibly to change its figure. Each time that it is set up to be tested, an interval of ten or fifteen minutes must be allowed to elapse to give it time to resume its normal shape.

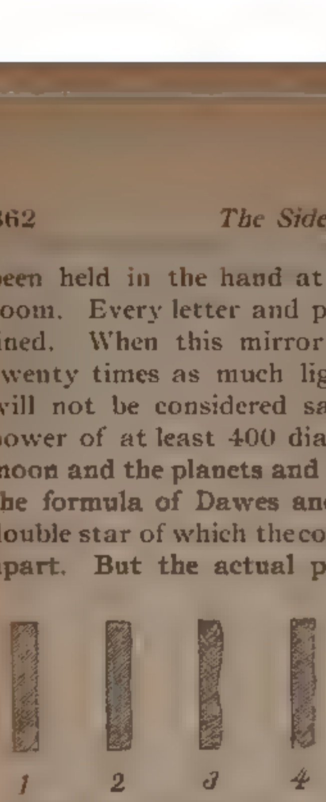
When the figure of the mirror has in this way been so far corrected that, as tested by the Foucault method, it is thought to be very nearly parabolic, a second and final test is applied to it. We need here merely indicate the nature of this test, without going into all its details. It is based upon the amount of the aberration in the case of a parabolic mirror, when it is made to reflect light radiating from the center of curvature. To confine our attention to the case in hand, it can be shown geometrically that, were this mirror of a parabolic figure, so that parallel rays from a very distant luminous point would all be brought to the same focus at a distance of five feet from its face, the rays from a point at ten feet distant would be so reflected that, while the central rays

would return exactly to the starting point, the focus of the outside rays would fall about .08 of an inch beyond. With this fact to work upon, an eye-piece is now brought into use, so mounted that by means of a lever it can readily be adjusted to .001 of an inch. The problem now is to make the mirror conform to its theoretical performance in its present position, supposing it to be parabolic. Three or four card-board screens are prepared, at the center of one of which is cut a hole an inch and a half in diameter and in the others, circles of a quarter of an inch in breadth and of different diameters. These screens are successively suspended in front of the mirror. By this means the central part of the mirror and a series of concentric circular sections of the rest of its surface may be examined separately, the proper focus of each section having been previously ascertained and marked upon an index card. The Foucault test also is used in connection with this, as it affords the best means of determining the regularity of the curvature and of detecting any local defects.

Our mirror, having been brought finally to respond satisfactorily to all these tests, was put again on a large polisher and was smoothed by a half hour's careful polishing. Being then laid aside for some hours, it was again tested and its performance being still satisfactory, the work of polishing was decided to be completed. One thing further remained to be done. With the utmost care it is impossible to make the figure correct to the extreme edge. The mirror was, therefore, now placed face downward upon the iron plate with which we started, and a quarter of an inch of its edge was ground off, leaving the polished surface with a diameter of but 6¼ inches, surrounded by a narrow border of ground glass.

It will naturally be asked what a mirror of this size will do. The following trial was made of this. It was temporarily mounted, while still unsilvered; a slip cut from a newspaper was posted at a distance of 450 feet and the improvised telescope was directed toward it. By using an eyepiece which gave a power of 300 diameters, this slip of paper was "brought" to a distance of about 1½ feet from the eye. Notwithstanding that the illumination was very faint, the paper could be read as easily as though it had

been held in the hand at that distance in a dimly lighted room. Every letter and punctuation mark was sharply defined. When this mirror is silvered it will reflect about twenty times as much light as now, and its performance will not be considered satisfactory if it does not bear a power of at least 400 diameters upon such objects as the moon and the planets and of 500 upon stars. According to the formula of Dawes and Foucault it should separate a double star of which the components are no more than 0″.75 apart. But the actual performance of the best telescope rarely comes up to its theoretical powers and we may be content in this instance with a separating power of 1″. This may be expressed more clearly by saying that if two small holes punctured in a plate of metal one-tenth of an inch apart were illuminated by a strong light placed behind the plate, they should be seen distinctly as two separate points of light at a distance of nearly one-third of a mile. The actual distance apart of the images of these holes at the focus of the mirror would be .0003 of an inch.



Sections of the Apparent Figure of a Mirror, tested by the Foucault Method. 1, Spherical. 2, Parabolic. 3, Hyperbolic. 4, Full of Rings.

A mirror is not a complete telescope, it is true, but it is the part most difficult to make. One who has succeeded with this part of the work, will have no trouble with the rest. To make a suitable tube, of wood or paper or sheet metal, to make a "flat" (like the large mirror made of glass and silvered) and to mount the instrument in some convenient way are comparatively easy matters. Eye-pieces can be purchased, if it is not convenient or desirable to make them.

Upon the making of the mirror, therefore, the first energies are to be expended. The description of the process given above is not designed to afford working directions; its purpose has been mainly to direct attention to a recognized field for amateur work and to exhibit the processes employed with sufficient fullness to show that they are really quite simple and such as almost anyone can hope to master with a little perseverance. Those who may wish for a more complete treatment of this subject, will find much use-

ful information in the article on *The Telescope*, by Sir John Herschel, in the *Encyclopedia Britannica*, and in Vol. XIV of the *Smithsonian Contributions* (1865), in which Professor Henry Draper gives a very complete account of the construction of a 15½ inch telescope, including a description of the process of silvering the mirror. In concluding, we advise the beginner not to be too ambitious, but to try his "prentice hand" on a mirror of no more than three inches in diameter, for which a disc of common plate glass ¼ or ⅜ of an inch in thickness will answer. A good telescope of so small an aperture even as this is by no means an instrument to be despised. The writer has a 3-inch reflector, of two feet focal length—so small an instrument as to appear almost as a toy—which bears a power of two hundred diameters. It gives very fine views of the lunar mountains, will show, with a fair amount of detail, the belts of Jupiter, the markings on Mars and the division in the ring of Saturn. With such an instrument one can examine any of the objects given in Webb's *Celestial Objects for Common Telescopes*.

THE RADIANT-POINTS OF METEORS.

W. H. S. MONCK.

For The Messenger.

Mr. Denning's Catalogue of Meteor-Radiants, published in the May number of the *Monthly Notices* of the Royal Astronomical Society, will, I believe, when fully examined, largely modify the views generally entertained by astronomers on the subject. It is, I believe, the most remarkable contribution to this branch of the science ever made (or likely to be made) by one man. The first point which it places in a clear light is the existence of stationary or long-continued radiants. Of these Mr. Denning now enumerates 45, and no small proportion of his 918 observed radiants belong to these 45 stationaries. But an examination of the catalogue leads me to think that the number of stationary radiants might be doubled without going beyond the limits of Mr. Denning's catalogue. It would occupy too much space were I to attempt to set out a detailed list of these additional stationaries. Some of them I shall have occasion to refer

to specially, but before doing so I shall give as an example one which I do not propose to use for any other purpose:

No. in Catalogue.	Radiant-Point.	Date.
433	70° + 66°	Aug. 21, 23.
477	70 + 65	Aug. 27, 29.
555	69 + 70	Sept. 17, 19.
672	70 + 65	Oct. 15, 20.
769	70 + 65	Nov. 13.
799	69 + 66	Nov. 19, 20.
856	70 + 67	Dec. 4, 8.

I think any one who will take the trouble of writing out Mr. Denning's catalogue, not in order of date but in order of right ascension or declination, will be satisfied that stationary or long-continued radiants are not the exception but the rule. I venture to put forward as a hypothesis that this is not merely the rule, but an invariable law, the exceptions being accounted for by the tenuity of certain showers and the want of sufficient observations. Thus, for instance, when the radiant is below the horizon, meteors from it are not likely to be observed; or when it lies to the west while the observer is looking east (as Mr. Denning generally did). Clouds and moonlight interfere with observations, and no observer is on the lookout every fine night, while Mr. Denning, with all his energy and perseverance seldom, if ever, watched through an entire night.

This hypothesis can hardly be reconciled with the cometary theory which is generally accepted, or with the shifting radiants which Mr. Denning thinks he has observed in several instances. I shall not, of course, altogether deny the influence of certain comets on certain meteor-showers but I think it is of a different character from what is generally supposed. In order to show this I shall endeavor to prove that the Perseid and Andromede radiants are stationary or long-enduring radiants which supply us with a considerable number of meteors when we are at a great distance from the comet's node.

PERSEID RADIANT.

(*Omitting the Numerous Observations in the First of August.*)

No. in Denning's Catalogue.	Radiant-Point.	Date.	
171	40° + 56°	June 14, 25.	
298	43 + 58	July 27, 31.	
422	40 + 59	Aug. 20, 21.	Mean Position
(Tupman)	(42 + 55)	(Sept. 5.)	44° + 56°
634	42 + 55	Oct. 6, 12.	
656	43 + 58	Oct. 8, 14.	
745	45 + 60	Nov. 7.	
830	44 + 56	Nov. 29.	
847	44 + 56	Dec. 1, 10.	

This table suggests that Mr. Denning was in error in describing this radiant as a shifting one, and that it is in fact continuously active without any material change in position from June to December. Mr. Denning has, I think, confounded the meteors derived from this source with those belonging to three other stationary radiants which appear thus in his catalogue:

FIRST STATIONARY RADIANT.

No. in Catalogue.	Radiant-Pt.	Date.	
188	3° + 49°	July 8, 11.	
199	6 + 53	July 12.	
219	5 + 52	July 16.	Mean Position
221	7 + 53	July 17.	6° + 52°
357	8 + 53	Aug. 10, 12.	
666	7 + 51	Oct. 15, 20.	
758	5 + 52	Nov. 10, 13.	

SECOND STATIONARY RADIANT.

149	20° + 58°	May 30.	
260	18 + 58	July 28.	
278	21 + 57	July 20, Aug. 1.	Mean Position
320	20 + 58	Aug. 2, 4.	20° + 57°
521	20 + 56	Sept. 13, 22.	
652	21 + 55	Oct. 14.	

THIRD STATIONARY RADIANT.

264	32° + 53°	July 27, 28.	
290	32 + 53	July 30, Aug. 1.	
311	33 + 55	Aug. 2.	Mean Position
443	32 + 50	Aug, 14, 23.	32° + 53°
514	33 + 54	Sept. 6, 9.	
587	31 + 52	Sept. 21, 25.	

Under the last of these heads I have omitted some of Mr. Denning's radiants which are nearly of the same date and value as those inserted.

These four radiants appear to be simultaneously active at the end of July and beginning of August, when they often seem to run into each other by imperceptible degrees, but in their later developments (as well as in the earlier developments of the principal radiant and that which I have described as the second stationary), they are easily distinguished, and I suspect that some radiants have been erroneously determined because meteors belonging to different neighboring streams happened to pass nearly through the same point. I desire to call attention to the fact that Mr. Denning has observed meteors from the radiants which I have described as the first, second and third stationaries in

the month of August throughout the whole of which month he ascribes a greater R. A. to the Perseids; in addition to which he has observed meteors from the true or principal Perseid radiant (44° + 56°) before the end of July. These facts seem to me to prove that we are dealing not with a shifting radiant but with several radiants which are in simultaneous action.

The Andromede shower of November 28 seems also to proceed from a fixed or stationary radiant, though Mr. Denning did not notice any meteors from it later than the principal shower. The following are the earlier appearances.

No. in Catalogue.	Radiant-Point.	Date.	
321	26° + 42°	Aug. 4, 10.	
401	22 + 46	Aug. 12, 16.	
411	25 + 42	Aug. 19, 21.	Mean Position
441	24 + 42	Aug. 21, 25.	25° + 44°
488	28 + 45	Sept. 4, 16.	
669	25 + 44	Oct. 14, 15.	
740	25 + 46	Nov. 4, 7.	
809	24 + 45	Nov. 25, 27.	

I think I am justified in concluding from these data, first, That the great majority of radiants are stationary or long-enduring. Second, that no shifting radiant has hitherto been conclusively proved; and third, that two at least of the supposed cometary showers proceed from stationary or long-continued radiants which are active even when the earth is a great distance from the node of the comet's orbit.

The question next comes, How can stationary radiants be explained? I venture to offer the following, not without some hesitation, as it has not been accepted by some mathematical friends to whom I communicated it.

Suppose, for illustration, that a river runs E. to W. with a raft floating down it close to the bank and that a number of balls are rolled over the bank in a direction N. to S. with a constant velocity, each of which rolls on to the raft. Now to a person on the raft the balls rolling across it seem to be travelling N. to S. no matter at what rate the raft is moving; for this person moves with the raft and is unconscious of his own motion. Again let the channel of the river take a bend to the N. the balls still seem to the man on the raft to move across it in the same direction (N. to S.) as before. The only difference is that the velocity is increased.

Let it now take a bend to the S. The direction of the balls is still unaltered. They only appear to roll across the raft with diminished velocity. In the case of the earth the atmosphere plays the part of the raft. It moves with the earth and the spectator moves with both. The meteor at the moment when it first becomes visible already partakes in the motion of the raft—that is of the air or of the earth; and as long as meteors reach us from the same direction we shall refer them to the same radiant. Stationary radiants therefore, simply mean that meteors come to us for months in succession from the same direction. The change in the earth's motion would not affect the apparent direction or radiant-point of the meteors but only their apparent velocity. And accordingly Mr. Denning notices that their apparent velocity *is* altered. Thus of a shower from another point in Perseus (47° + 44°) he says: "In July and August they move very swiftly and leave bright streaks. In September the motions are still very swift but the meteors are then devoid of streaks except in the more brilliant instances. In October the speed has palpably slackened, my description of the flights being 'moderately swift,' while in the middle of November I estimated them as 'rather slow.' At the end of that month and early in December my records give 'slow' and 'very slow,' and this also applies to the meteors of this radiant seen between December 18—January 11 and February 23—March 12" (*Monthly Notices* vol. 50, p. 416). This extract sufficiently disposes of the theory of the late Mr. Proctor that these radiants appeared to be stationary because the velocity of the component meteors was very great compared with that of the earth. Some of them are *very slow* according to Mr. Denning but their velocities vary at different times as on my hypothesis they ought to do. The earth is receding from the radiant in question when the observed motion is slow and approaching it when the observed motion is fast.

But how on this hypothesis can the influence of the comets on certain showers be explained. On this point I can only offer a conjecture. Suppose in the illustration already given that the balls are electrified and that suddenly a large oppositely electrified body moves down through them in a direction nearly N. to S. Evidently the effect will be to draw the balls toward the track of this large body and thus ren-

der them thicker near the track than at a distance from it; and thus even if the large body stops before reaching the bank of the river more balls will roll on to the raft at its point of nearest approach than elsewhere. The effect will be more marked if the large body crosses the river; and I may add that a slight shifting of the radiant might arise owing to the balls being drawn slightly out of their course by the attraction. Substituting gravitation for electricity the result is unaltered. A comet running through a meteor-cloud would cause the meteors to become thicker about its track and thinner outside of it and might also occasion a slight shifting of the radiant.

The changes in the velocity of the meteors referred to the four stationary radiants in Perseus are exactly what they ought to be on the hypothesis which I have now put forward. The early meteors from all four radiants are described as swift and usually as accompanied by streaks. At No. 521 (Sept. 13, 22) I first meet the word "slowish" No. 587 (Sept. 21, 25) is also "slow." And from this to the end all the streams are described as slow with two or three dubious exceptions. With the Andromedes also I find that while the meteors in the well-known November shower are slow the August meteors from the same radiant are described as swift, the September as rather swift and the October slow. In fact the meteors from every radiant in this part of the sky slacken their speed between August and November as they ought to do on my hypothesis.

In conclusion I may remark that the close agreement of the orbits of four meteor-showers with those of four known comets depends to a great extent on uncertain estimates of the velocities of the meteors. A swifter or slower motion would derange the supposed orbits materially and I suspect that the estimated velocity of the meteor has sometimes depended on theoretical considerations rather than actual observation. In the case of a large Andromede fireball which was observed at a number of different places some years ago, Col. Tupman, from the observations, computed an orbit differing considerably from that of Biela's comet, the eccentricity being small and the period only 462 days. This orbit is more consistent with the theory of Tschermak and Sir Robert Ball than with the cometary theory.

July 19, 1890.

VISUAL OBSERVATION OF THE SURFACE OF MARS.

WILLIAM H. PICKERING.

FOR THE MESSENGER.

In connection with the series of photographs of this planet taken upon Mt. Wilson, and referred to in the June number of THE MESSENGER, a careful series of visual ob-visual observations have been made at Cambridge by the writer with the Boyden 12-inch refractor. The points to which especial attention has been directed are primarily the colors exhibited by the planet, and secondarily the delineation of the finer detail upon its surface. Regarding the latter there is no question but Green's map (Mem. Roy. Ast. Soc., Vol. XLIV., p. 123) gives much the best idea of the appearance of the planet and the general shape of the details of anything yet published. On the other hand there is considerable fine detail which is not given by Green, which is certainly seen in Cambridge, and which agrees more or less with that represented by Schiaparelli (Reale Accad. dei Lincei, 1886, Vol. III., p. 281). It seems to me most unfortunate that the name of canals has been attached to these finer markings upon the planet, for there has not been the slightest evidence brought forward in support of the supposition that they are filled with water, and such a supposition is, to say the least of it, very improbable.

The easiest one of all the canals to see is that shown by Green under the name of Nasmyth Inlet, and which Schiaparellli indicates by two very faint lines to which he gives in various portions of their length the names of Protonilus, Ismenius Lacus, Deuteronilus, and Jordanis. Schiaparelli's Boreosyrtis and Astapus are also readily seen. With these exceptions it was a long time before I could detect any of Schiaparelli's canals. This I afterwards found was in part due to my using too high a power, and in part to my eye being unaccustomed to the work. Now even when the seeing is only moderate, there is no difficulty in also seeing Styx, Fretum Anian, and Hyblaeus. Several other canals in this same region have been recognized, including Cerberus, Eunastos, Hephæstus, Alcyonius, Cyclops, and Laestrygon. These have all been discovered independently of the map,

and represented on at least two separate drawings. I have not yet been able to double any of them, or to see many of the fainter ones, but I have the highest admiration for the eyesight of the astronomer who could discover them in the first place with an 8-inch telescope. Now that their existence is known, there should be no difficulty for anyone with a little practice and moderate eyesight in seeing the more conspicuous ones, with a telescope of ten or twelve inches aperture. Save under exceptional circumstances the power employed should not exceed one or two hundred.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be "morning star" during October, having just passed inferior conjunction. He will be at greatest elongation west from the sun on October 14, rising then about an hour and a half earlier than the sun. For a few days about that time it will be visible to the naked eye in the morning, near the east point of the horizon.

Venus is the brilliant "evening star" seen in the southwest after sunset. She will be at her greatest brilliancy October 29, but is rapidly approaching inferior conjunction so as to be visible but a short time in the evening. The diameter of Venus' disk increases from 28″, October 2, to 44.4″, November 2; while the phase decreases in the same time from 0.439 to 0.224. An interesting article on the planet Venus by Professor G. V. Schiaparelli of the Milan Observatory, is contained in *L'Astronomie* for August, 1890. The writer discusses the observations of the elder Cassini and Bianchini, and concludes that there is no good ground for the assumption of $23^h\ 20^m$ as the rotation period of Venus. This period was not derived by the elder Cassini, but by his son, who himself could identify none of the markings which his father saw upon the planet. The period of about twenty-four days would much better satisfy the observations of Bianchini and equally well those of Cassini. Whether this period is one of rotation or of a large libration, like that of Mercury, cannot be decided from the data at hand.

Mars is still visible in the southwest in the evening, his course this month being eastward through the constellation Sagittarius. Very little has come to hand concerning physical observations of *Mars*, except the interesting article by Professor Pickering, which is given elsewhere in this journal.

Jupiter is in good position for observation in the early evening, but his low altitude in northern latitudes is unfavorable to the study of minute details of his surface. The great red spot, while not conspicuous, is more easily seen than during last year. It preserves the form of an oval ring and

its position relative to the great southern belt remains unchanged. An interesting paper on the belts and markings of Jupiter, by Mr. N. E. Green, is contained in the *Memoirs of the R. A. S.*, Vol. XLIX. It is the result of the study of a series of drawings of Jupiter, made by the writer during the period from 1859 to 1887. We quote some of the conclusions derived:

"It may be fairly concluded that Jupiter is surrounded with an atmosphere. That this atmosphere contains a large amount of vapor which is condensed, under varying circumstances, into forms greatly resembling those of terrestrial clouds. That from 60° to the poles this vapor forms quiescent and nearly unchanging caps of cloud. That this amount of condensation suggests the existence of extensive areas of water. That from 45° to the equator, both on the north and south, the planet is in a state of constant change, not only in its superficial markings, but also in the surfaces which underlie its atmosphere. That, notwithstanding this tendency to change, forms having considerable permanence are possible. That such forms are possible only in the direction of revolution, as is evidenced by the shape of the red spot, and the smaller spots following it in 1885, and therefore, all forms, whether of land or water, or intermediate states of matter, must agree with the direction of the belts. That although Jupiter may retain a large amount of original heat, it is not to any extent incandescent. This view is supported by the fact that the most frequent changes are confined to a space extending 45° on each side of the equator, or to that part most under the influence of the sun, indicating that the power producing these changes comes principally from without, and that the changes are chiefly of an atmospheric character. This remark does not apyly to the red spot, or to the copper color of the equator and belts, which in all probability were due to the action of forces within the body of the planet."

Saturn may be seen toward the east in the morning a couple of hours before sunrise. The angle of the earth below the plane of the rings is less than 5°, so that the details of the surface of the rings can be seen only with difficulty.

Uranus cannot be seen during this month. He will be in conjunction with the sun October 20. On April 13, 1890, two observers at Lick Observatory, with the 36-inch telescope, were satisfied that the planet Uranus had two faint bands on its surface. Their position angle was estimated at 90° ± by Professor Holden and 105° ± by Professor Schæberle. These results for position angle differ greatly from those obtained by Perrotin at Nice.

Neptune is visible all night after 8 P. M. He may be found with a telescope of 6 inches aperture about 1° north and 30′ east of the star Epsilon Tauri.

MERCURY.

Date.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Oct. 25	13 10.3	− 5 23	5 12 A. M.	10 54.2 A. M.	4 36 P. M.
Nov. 5	14 17.3	− 12 44	6 06 "	11 17.9 "	4 30 "
15	15 20.3	− 18 33	6 54 "	11 41.2 "	4 28 "

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
			VENUS.		
Oct. 25	16 46.1	− 27 34	10 28 A. M.	2 29.3 P. M.	6 30 P. M.
Nov. 5	17 08.0	− 28 02	10 10 "	2 08.1 "	6 07 "
15	17 13.2	− 27 21	9 32 "	1 34.0 "	5 36 "
			MARS.		
Oct. 25	19 35.4	− 23 45	12 57 P. M.	5 18.4 P. M.	9 40 P. M.
Nov. 5	20 08.9	− 22 05	12 37 "	5 08.4 "	9 39 "
15	20 39.1	− 20 11	12 20 "	4 59.2 "	9 38 "
			JUPITER.		
Oct. 25	20 24.2	− 20 08	1 27 P. M.	6 06.9 P. M.	10 47 P. M.
Nov. 5	20 28.8	− 19 51	12 48 "	5 28.4 "	10 09 "
15	20 34.2	− 19 32	12 12 "	4 54.3 "	9 37 "
			SATURN.		
Oct. 25	11 02.9	+ 7 56	2 12 A. M.	8 47.3 A. M.	3 22 P. M.
Nov. 5	11 06.8	+ 7 35	1 34 "	8 07.8 "	2 41 "
15	11 09.7	+ 7 19	12 59 "	7 31.5 "	2 04 "
			URANUS.		
Oct. 25	13 42.5	− 10 03	6 03 A. M.	11 26.3 A. M.	4 50 P. M.
Nov. 5	13 45.1	− 10 18	5 23 "	10 45.7 "	4 08 "
15	13 47.4	− 10 31	4 47 "	10 08.6 "	3 30 "
			NEPTUNE.		
Oct. 25	4 18.7	+ 19 43	6 34 P. M.	2 00.1 A. M.	9 26 A. M.
Nov. 5	4 17.6	+ 19 41	5 50 "	1 15.7 "	8 42 "
15	4 16.5	+ 19 38	5 09 "	12 35.3 "	8 01 "
			THE SUN.		
Oct. 20	13 41.4	− 10 31	6 23 A. M.	11 44.8 A. M.	5 06 P. M.
25	14 00.4	− 12 16	6 30 "	11 44.1 "	4 58 "
30	14 19.8	− 13 57	6 37 "	11 43.7 "	4 51 "
Nov. 5	14 43.4	− 15 51	6 45 "	11 43.7 "	4 43 "
10	15 03.5	− 17 18	6 56 "	11 44.1 "	4 32 "
15	15 23.9	− 18 38	6 58 "	11 44.8 "	4 33 "
			THE MOON.		
Oct. 20	19 47.8	− 24 26	1 26 P. M.	5 50.2 P. M.	10 17 P. M.
25	0 40.1	− 0 49	4 19 "	10 22.1 "	4 34 A. M.
30	5 14.5	+ 23 27	6 43 "	2 36.1 A. M.	10 35 "
Nov. 4	9 45.5	+ 18 36	11 08 "	6 46.7 "	2 16 P. M.
10	13 40.0	− 6 08	4 26 A. M.	10 21.0 "	4 05 "
15	18 23.7	− 25 09	10 21 "	2 44.1 P. M.	7 05 "

Phases and Aspects of the Moon.

			Central Time. d	h	m
First Quarter	1890	Oct.	21	1	36 A. M.
Full Moon	"	"	27	5	42 P. M.
Last Quarter	"	Nov.	4	10	13 A. M.
New Moon	"	"	12	7	38 "
Perigee	"	Oct.	24	4	00 "
Apogee	"	Nov.	5	3	12 "

Phenomena of Jupiter's Satellites.

d.	Central Time. h. m.				d.	Central Time. h. m.		
Aug. 26	6 31 P. M.	I.	Sh. Eg.		Nov. 2	6 07 P. M.	I.	Sh. In.
26	6 49 "	III.	Ec. Re.		2	7 02 "	I.	Tr. Eg.
30	7 37 "	II.	Sh. In.		3	5 45 "	I.	Ec. Re.
30	7 50 "	II.	Tr. Eg.		9	6 09 "	III.	Oc. Dis.
Nov. 2	5 41 "	III.	Oc. Re.		13	5 05 "	III.	Sh. Eg.

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N.P't. °	Duration. h m
Oct. 14...	κ Virginis	4	6 09	21	Star 1.3′ N of moon's limb		
23...	τ^2 Aquarii	4	6 15	335	" 1.2′ " " " "		
31...	5 Geminorum	6½	11 46	95	12 59	237	1 13
Nov. 1...	52 "	6½	17 01	63	18 16	314	1 14

COMET NOTES.

Comet 1890, II. (Brooks, March 19.)—This comet will be in the same right ascension with the sun Oct. 11, but will then be 34° north of the sun, so that it will not set until about three hours after sunset. It is doubtful whether it can be seen in the twilight. The following ephemeris by Dr. Berberich is taken from *Astr. Nach. No. 2984*.

1890		α app.	δ app.	log r	log Δ	H
Oct.	4	13ʰ 4ᵐ 56ˢ	+ 28° 49.0	0.3872	0.5058	0.53
	5	5 9	28 41.0			
	6	5 23	28 33.2			
	7	5 36	28 25.6			
	8	5 50	28 18.2	0.3924	0.5086	0.51
	9	6 3	28 11.0			
	10	6 17	28 3.9			
	11	6 30	27 57.0			
	12	6 44	27 50.2	0.3976	0.5107	0.49
	13	6 57	27 43.6			
	14	7 10	27 37.2			
	15	7 23	27 31.0			
	16	7 36	27 25.0	0.4028	0.5123	0.48
	17	7 49	27 19.2			
	18	8 1	27 13.5			
	19	8 14	27 8.0			
	20	8 26	27 2.7	0.4080	0.5134	0.46
	21	8 38	26 57.6			
	22	8 50	26 52.6			
	23	9 2	26 47.9			
	24	9 13	26 43.4	0.4133	0.5138	0.45
	25	9 24	26 39.1			
	26	9 35	26 34.9			
	27	9 45	26 30.8			
	28	9 55	26 26.6	0.4185	0.5137	0.44
	29	10 5	26 23.2			
	30	10 14	26 19.6			
	31	10 23	26 16.3			
Nov.	1	10 31	26 13.2	0.4237	0.5130	0.43
	2	10 39	26 10.3			
	3	10 46	26 7.7			
	4	10 53	26 5.3			
	5	13 11 0	+ 26 3.0	0.4288	0.5118	0.42

Comet 1890......(Denning July 23.)—This comet is about three hours and a half east of the sun, and moving rapidly southward, through the constellation Scorpio. On Oct. 18, it will pass very near the bright star Antares. Its brightness is diminishing rapidly, so that it is doubtful whether it can

be seen with small telescopes. Mr. Wendell's ephemeris given below will enable the possessors of powerful telescopes to follow the comet for a short time at least.

Ephemeris of Comet C, 1890. (*Denning July 23.*)

Gr. M. T.		App. R. A. h	m	s	App. Dec. °	′	Log. r.	Log. Δ.
Oct.	1.5	16	5	32	− 11	9	0.1100	0.2051
	2.5		6	30	12	2		
	3.5		7	28	12	55		
	4.5		8	28	13	46		
	5.5		9	27	14	37	0.1121	0.2227
	6.5		10	27	15	26		
	7.5		11	26	16	14		
	8.5		12	27	17	2		
	9.5		13	28	17	48	0.1151	0.2398
	10.5		14	29	18	34		
	11.5		15	30	19	19		
	12.5		16	32	20	3		
	13.5		17	34	20	46	0.1190	0.2563
	14.5		18	36	21	28		
	15.5		19	39	22	10		
	16.5		20	42	22	51		
	17.5		21	46	23	31	0.1238	0 2720
	18.5		22	51	24	11		
	19.5		23	55	24	50		
	20.5		25	0	25	28		
	21.5		26	26	26	6	0.1293	0.2869
	22.5		27	12	26	42		
	23.5		28	19	27	19		
	24.5		29	26	27	55		
	25.5		30	34	28	30	0.1354	0.3009
	26.5		31	42	29	5		
	27.5		32	51	29	39		
	28.5		34	0	30	13		
	29.5		35	10	30	46	0.1422	0.3141
	30.5		36	20	31	19		
	31.5	16	37	30	−31	51		

O. C. WENDELL.

Harvard College Observatory, Sept. 20, 1890.

Solar prominences for July 1890. Number of observations, 12; number of prominences, 29; mean number of prominences, 2.416; highest prominence, 62″ (on the 31st).

DISTRIBUTION OF PROMINENCES.

Between	E. Limb.	W. Limb.	Between	E. Limb.	W. Limb.
0 and + 10°	0	0	0 and − 10°	0	3
+ 10 and + 20	1	0	− 10 and − 20	0	3
+ 20 and + 30	1	0	− 20 and − 30	1	4
+ 30 and + 40	0	0	− 30 and − 40	1	1
+ 40 and + 50	4	1	− 40 and − 50	3	0
+ 50 and + 60	0	3	− 50 and − 60	2	0
+ 60 and + 70	0	0	− 60 and − 70	0	0
+ 70 and + 80	0	0	− 70 and − 80	0	0
+ 80 and + 90	0	0	− 80 and − 90	0	0
				13	15

NOTE: During the month definition has been so poor here that I may have failed to see faint prominences. This would account for the small mean number.

E. E. REED, JR.

Camden Observatory, Aug. 1, 1890.

Smith Observatory Solar Observations. **The following observations of the sun were made with the telescope except when otherwise specified. Those of June 12, 19, 23, 24, 25, 28 and on to August 16 were made by Charles E. Peet:**

1900.	90° Mer. M. T.	Groups.	Spots.	Faculae.	Seeing.	Remarks.
May 16	12 m.	0	0	0	Good	Gran good, both coarse and fine.
17	2:30 p m	2	4	1	Poor	Fac disturbance about spots near E. limb.
18	2:45 p m	1	1	0	Fair.	Gran fair at intervals.*
19	5 p m	2	4	0	Poor.	Seeing too poor to distinguish minute spots.*
20	11:45 a m	2	4	1	Fair.	Faint faculae on E limb
21	5 p m	2	2	2	Very good.	Brilliant lines of faculae extending from S. group to limb
23	4.30 p m	1	3	2	Fair	Faint fac like penumbra about two of the spots, one minute and very black
24	2 p m	0	0	1	Fair	Gran good * Only a moment through a rift in the clouds.
26	9:45 a m	2	3	1	Fair	Fac near W limb; fac mottling all over disc Gran good
27	11.30 a m	0	0	1	Fair	One good group fac near W limb *
28	2 p m	0	0	1	Fair.	Gran fair, faint fac near E limb *
29	9:30 a m	0	0	0	Good	No distinct fac Gran very good to limb
30	4 p m	0	0	1	Good	Gran good, small gr fac quite near SW limb *
31	4.45 p m	0	0	0	Fair	Gran fair Fac mottling near N limb
June 1	5 p m	0	0	0	*Haze & clouds*	Nothing visible. Too indistinct
2	4 45 p m	0	0	0	Good.	Gran very good to limb
3	5 p m	0	0	0	Good	Gran good with power 221
4	4.15 p m	1	4	1	Fair	One group very bright fac SE limb Gran good
5	2:00 p m	1	10	1	Fair	Gran good Spots mostly very minute.
6	4.30 p m	1	10	1	Good	All but four spots very indistinct; faint fac. on W limb
7	4.30 p m	1	7	0	Bad	Gran poor, limb very unsteady
8	3.15 p m	1	3	1	Poor	Too near W limb to count accurately
10	3 30 p m	1	3	1	Fair	Spots very faint surrounded by disturbed region
11	4 p m	0	0	3	Poor	Gran poor, fac. on W & SW limb
12	1:45 p m	0	0	1	Fair	Gran fair, fac near W limb
15	4 p m	0	0	0	Poor	Fac mottling on E and W limbs
16	4:30 p m	0	0	1	Good.	Gran good Continuous groups fac on W limb.
19	2 p m	0	0	1	Fair	Gran surface fair
21	5 p m	0	0	0	Fair	Gran quite good
22	4 p m	0	0	2	Fair	Faint fac on NE and SE limb
23	4 p m	0	0	0	Good	Gran good
24	2 p m	0	0	0	Fair	Gran fair, glimpsed through clouds.
25	2 p m	0	0	0	Good	Gran good
26	2:15 p m	0	0	0	Fair	Gran good.
27	4.45 p m	0	0	0	Rem'k'bly g'd	Gran sharp and distinct.
28	5 p m	0	0	0	Good.	Gran good
29	3 p m	0	0	0	Poor.	Gran fair
30	2 p m	0	0	0	Poor	Gran difficult.
July 1	2 p m	0	0	0	Poor.	Gran fair
2	11 a m	0	0	0	Poor	Gran difficult.
3	4 p m	0	0	0	Fair	
4	2 p m	11	7	1	Fair	Spots surrounded by fac. region
6	9 a m	1	9	1	Poor.	Spots surrounded by fac. region.
7	3:30 p m	1	40	1	Good	Many of the spots counted are minute.
8	3:30 p m	1	11	0	Bad.	Seeing too poor to distinguish faint spots.
9	9 a m	1	27	1	Fair	Fac. region about spots.
10	10 a m	1	23	1	Good.	Fac region about spots.
11	9 a m	1	20	1	Poor	Fac about E group
12	6:45 p m	1	3	0	Bad	Seeing too poor to distinguish small spots.
13	3 p m	1	3	1	Poor.	Group of fac near E. limb
14	6:30 a m	1	2	2	Bad	Gran. difficult.
15	9:15 a m	0	0	2	Fair	Fac. on SW and NE limbs.
16	9:15 a m	0	0	3	Good.	
17	10 a m	1	1	0	Fair	
18	8:15 a m	0	0	0	Good.	Gran. good
19	3 p m	0	0	1	Bad.	
20	3 p m	0	0	0	Poor.	
21	10:45 a m	0	-	0	Fair.*	

* Projection on 20 cm. circle.

1890.	90° Mer M. T.	Groups	Spots	Faculæ	Seeing	Remarks.
22	3 p m	1	2	0	Poor	Penumbra about each spot.
23	1:30 p m	1	3	0	Fair	Glimpsed through clouds.
25	11.15 a m	1	5	1	Fair *	Fac. region about group.
26	7.30 a m	1	6	1	Fair.	Fac. region faint
27	6:30 a m	1	8	1	Good	Faint faculous region about spots.
28	3 p m	2	6	1	Poor	Gran. good
29	9 a m	3	5	3	Poor.	Gran. difficult.
30	4:45 p m	2	5	2	Good	Gran. good.
31	5.45 a m	2	4	3	Fair *	Gran. good.
Aug 1	3 p m	2	7	3	Fair	
2	12:30 p m	3	6	5	Fair *	Bright fac. near S and NW limbs.
3	3 p m	1	1	3	Poor.	Faculæ faint.
4	3 p m	1	5	0	Bad.	Glimpsed through clouds.
5	10:30 a m	2	6	1	Bad *	Gran. difficult.
6	2:45 p m	2	5	0	Good *	
7	11:15 a m	2	3	2	Good	
8	5:30 p m	2	4	1	Fair	Spots in N W group very minute.
9	11 15 a m	0	0	1	Fair	Fac. mottling on W and SW limbs.
10	4 p m	0	0	1	Fine	
11	1.45 p m	0	0	0	Bad	Gran. difficult
13	5:45 p m	0	0	1	Bad *	
14	6:15 a m	0	0	0	Bad *	Gran. difficult.
15	8 a m	0	0	0	Good	Gran. good
17	6:15 p m	0	0	1	Fair	
18	1:30 p m	0	0	0	Bad	Seeing very bad; haze
19	1 15 p m	0	0	1	Fair	
20	3 15 p m	0	0	0	Fair	Gran. fair.*
21	9 45 a m	0	0	0	Fair	Gran. difficult.
22	2:30 p m	1	2	0	Fair	Gran. fair [visible
23	3.45 p m	0	0	0	Bad	Seeing very bad; hazy, no large spot
25	4.15 p m	1	6	1	Good	Facular disturbance about group.
26	1:50 p m	1	10	1	Good	Easternmost and westernmost spots have nuc. and penumbra.
27	1:30 p m	2	11	2	Poor	11 large spots and many smaller ones, haze
28	9:30 a m	1	15	0	Fair	2 spots with nuc. and penumbra.
29	3.15 p m	1	40	0	Fine	Gran. good
30	4 p m	1	41	0	Fine	
31	4:35 p m	1	34	1	Good	Fac. region about spots
Sept. 1	2 20 p m	2	25	0	Bad	4 spots in gr. 1 with nuc. and penumbra *
2	2 15 p m	2	34	0	Fair.	Single glimpse through clouds. Unable to complete observation *
4	11 10 a m	2	21	2	Fair	Glimpsed through clouds. Fac. disturbance about each group *
6	2 15 p m	2	12	1	Fair	Glimpsed through clouds Bright fac. reg. about group in N hemisphere
6	12:45 p m	3	16	2	Fine	2 spots in gr 1 with nuc and pen.*
7	5 p m	3	7	3	Bad	Glimpsed at intervals through clouds.*
8	2:25 p m	3	9	2	Bad	Haze *
9	4 45 p m	2	4	0	Bad	Haze too thick to distinguish well.*
10	2:35 p m	1	0	0	Bad	Gran. difficult Haze.*
11	1 10 p m	2	7	1	Fair	Gran. difficult
13	2 10 p m	0	0	0	Poor	Gran. fair
14	2:25 p m	0	0	0	Bad	Gran. difficult

* Projection on 20 cm circle.

Four New Asteroids have been discovered since our last issue. No. 295 was discovered by Palisa at Vienna, Aug 17.50 Gr. m. t.; R. A. = $23^h\ 00^m\ 28^s$, Decl. = $-2°\ 24'$, daily motion -40^s and $-3'$. No. 296 was discovered by Charlois at Nice, Aug. 19. Its position Aug. 21.4749 Gr. m. t. was: R. A. = $22^h\ 16^m\ 54.4^s$, Decl. = $-12°\ 20'\ 24''$; daily motion -13^s and $-6'$. Nos. 297 and 298 were discovered by Charlois at Nice, on the same night, Sept. 9. Their positions were: Sept. 9.3857 Gr. m. t.; R. A. = $22^h\ 21^m\ 48.5^s$, Decl. = $-9°\ 02'\ 28''$ and Sept. 9.5364 Gr. m. t; R. A. = $0^h\ 38^m\ 32.9^s$, Decl. = $+2°\ 40'\ 04.''$ Daily motion of No. 297: -48^s and $-1'$; of 298 -56^s and $-1'$ No. 297 was of the 12th magnitude, the others of the 13th magnitude.

NEWS AND NOTES.

From what was said in our last issue, some have thought that the MESSENGER would be published hereafter every month in the year. This is a mistake, ten numbers will make an annual volume as heretofore.

On account of unexpected delays in securing photographs and suitable plates from engravers, we are unable to give frontispiece and biographical sketch this month, as was intended.

Since the article entitled stationary and long-enduring Meteor-Radiants by W. H. S. Monck, of Ireland, was in type, we have received a printed copy of the same matter in more extended form. Our vacation months have delayed the appearance of this paper and the later edition of it has already been published, as Mr. Monck informed us he intended to do some weeks ago.

A general list of observatories, astronomers, societies and astronomical journals has been prepared by A. Lancaster, Librarian of the Royal Observatory of Brussels. This third and last edition is a very useful reference book.

New Telescope for the University of Mississippi. In a recent letter from Professor R. B. Fulton, in charge of the department of Physics and Astronomy of the University of Mississippi we learn that a new telescope of considerable size will soon be ordered for the Observatory of that institution.

Portrait of Dr. Peters. Henry Harrison, of South Bergen, N. J., has just completed a life-sized portrait of the late Dr. Peters of the Observatory of Hamilton College, Clinton, N. Y. It is designed for the library of the college.

Polaris and Companion. We have had considerable correspondence lately concerning the appearance of the companion to Polaris. Amateur observers are requested to keep close watch of it, and to report anything unusual observed.

The New Equatorial Telescope for Carleton College Observatory. We have recent information from the makers of the rough discs for the new 16-inch equatorial for Carleton College Observatory, relating to progress of work on the same. Messrs. Shott & Gen, of Jena, have finished the flint disc, and it was shipped early last month. Mantois, of Paris, a few weeks ago had nearly completed the annealing of the crown disc. When these rough discs come into the hands of Professor Hastings of Yale University, and Mr. Brashear, of Allegheny, they will be thoroughly tested a second time before grinding begins. These well-known European makers of large optical discs seem already interested in the comparative merits of their work. It isnow believed that Carleton's new telescope will be in place about May 1, 1891.

J. E. Ingraham, President of the South Florida Railroad Company at Stanford, Florida, an interested subscriber to THE MESSENGER, has recently purchased a 4½-inch equatorial, and is planning to do regular observing with it.

Another Telescope for Chicago. We are interested to learn that Mr. George E. Hale of Chicago, Ill., is soon to have a new 12-inch equatorial especially adapted for spectroscopic work. Mr. Brashear is making the glasses and Warner & Swasey the mounting and dome. The dome is to be 26½ feet in diameter, and is the same size as the smaller one for the new Naval Observatory at Washington, D. C., the larger one being 45 feet in diameter. These three domes are now being made by Warner & Swasey, Cleveland, Ohio.

Perpetual Calendar. Some time ago we received from Professor R. W. McFarland a very neat form of a perpetual calendar. We will soon find a place for it in the MESSENGER.

Canals of Mars. We were so much interested in a private letter received in August from Professor W. H. Pickering, concerning the Canals of Mars, that we immediately asked him to give the benefit of his views to our readers. His important article is given in this issue.

Astromical and Physical Society of Toronto. Some years ago the Astronomical and Physical Society of Toronto was formed, but recently it has been incorporated and has adopted a Constitution and By-Laws, which has been printed in neat form and distributed as the first publication of the society. A circular setting forth its objects, and something of its plan of work is also received. Membership fees are $2 per annum. President, Charles Campbell, F. R. A. S., Director of the Toronto Observatory; Recording Secretary, D. J. Howell, 218 Becker Street, Toronto and Corresponding Secretary, G. E. Lumsden, Toronto. The new society is now in shape for work, and evidently means business.

A New Astronomical Society has been formed in England for the purpose .of organizing and directing the energies of amateur observers in astronomical study. This movement is outside the province of the Royal Astronomical Society, whose fees and papers generally are beyond the ability of many who could work well in an organization differently constituted. The movement is a good one, and if rightly planned and directed must succeed.

Photographic Notes: The next meeting of the permanent committee on the photographic chart of the heavens will be held March 31, 1891.

In the Observatory for August, Mr. Common describes his instrument for measuring celestial photographs. It is in general plan like Mr. Robert's instrument for engraving from original negatives.

"The South American scientific party lately took some photographs of

the planet Mars. The pictures show the spots and markings on the planet very clearly. One of the negatives shows the Southern snow-cap distinctly larger than those taken the evening before."—*Photographic Times.*

The recent Lunar photographs of the Henry Brothers are exciting much interest. These are the pictures of the north and south horn of the moon, taken with the photographic telescope of the Paris Observatory. These pictures are enlarged to a scale of one metre to the diameter of the whole moon.

Knowledge for September contains parts of a photographic map of the normal solar spectrum made by Mr. George Higgs. These photographs are accompanied by an article by Mr. Ranyard on "Recent Advances in the Mapping of the Solar Spectrum." Mr. Ranyard's paper is full of suggestions as to the sensitizing of plates to different lights, kinds of instruments, their arrangement and method of use. As to Mr. Higgs' instrument, he makes the following statements: "The concave grating used by Mr. Higgs is mounted on one side of a circular table, ten feet two inches in diameter. The sensitive plate on which the normal spectrum is thrown is at the opposite extremity of the diameter of the circumference of the table, and the slit is also mounted on the circumference of the circle, in a position with respect to the grating and sensitive plate which varies according to the order of the spectrum, which is being photograph. The light of the sun it thrown by a heliostat upon the slit." The Henry Brothers have secured satisfactory photographs of stellar spectra.

Dr. H. C. Wilson has recently taken two excellent photographs of lightning. These pictures clearly show interesting details of the flash, and also bring out by lightning light, the foliage of trees within the range of the lens.

Stars having Peculiar Spectra. [Communicated by Edward C. Pickering, Director of Harvard College Observatory.] Photographs of stellar spectra taken at the Harvard College Observatory, and also at Mt. Harvard, near Chosica, in Peru, show a number of objects whose spectrum is peculiar in addition to those already published in THE SIDEREAL MESSENGER. Among them are the following stars:

No.	R. A. 1900.	Dec. 1900.	Magn.	Description.
A. G. C. 7179	5^h 59.4^m	$-$ 6° 42′	5.8	F line bright.
" 15177	11 0.8	$-$ 65 1	8½	Bright lines.
" 18859	13 47.7	$-$ 46 39	6.6	F line bright.
" 19737	14 29.2	$-$ 41 43	2.5	F line bright.
Z. C. 3612	17 55.1	$-$ 32 42	9	Bright lines.
DM $-$ 19°4854	18 2.1	$-$ 19 25	9.6	Bright lines.
DM + 30°3639	19 31.9	+ 30 19	9.3	Bright lines.
A. G. C. 29232	21 13.6	$-$ 45 27	6.0	IV Type.

A. G. C. 19737 is η Centauri. As A. G. C. 18859, δ Centauri and μ Centauri are near, they form a group of stars in which the F line is bright. γ Cassiopeiæ, which has a similar spectrum is nearly 180° distant from this group. A. G. C. 15177, Z. C. 3612, and D. M. — 19° 4854 have a spectrum similar to that of the stars discovered by Rayet. The spectrum of DM + 30° 3639 differs from that of the other bright line spectra of which photographs have been obtained. A photograph of the spectrum of G. C.

2581 has also been taken. It seems to be peculiar, and is the same as that of G. C. 4628. In the *English Mechanic* Mr. D. Packer calls attention to two new variable stars, one preceding, the other following the cluster 5 M Libræ. Seventeen plates covering that region have been examined and measured here, and prove beyond doubt the variability of these two stars, the measures of the three comparison stars used differing by only 3, .3 and 6 respectively, while the measures of the variables show a variation of 1.9 and 2.9 magnitudes respectively. Three stars were found having a spectrum in which the lines due to hydrogen were bright. These stars were at once suspected of variability, which was confirmed on examination of the photographic charts previously taken. They are in the constellations Cælum, Scorpius, and Sagittarius, and have the following approximate places for 1900 R. A. 4^h 37.1^m, Dec. $-38° 33'$; R. A. 16^h 48.4^m, Dec. $44° 57'$, and R. A. 20^h 11.1^m, Dec. $-39° 25'$. M. FLEMING.

Harvard College Observatory, Cambridge, Mass., Sept. 12, 1890.

Astronomy at the Indianapolis Meeting of the A. A. A. S. Section A. (Mathematics and Astronomy) of the A. A. A. S. was but slimly attended this year. As a result there were but few papers, but these were of considerable interest.

The address of Vice-President Chandler on the Variable Stars was a most elaborate and painstaking review of the work done in this branch of Astronomy. Of the greatest value and interest was a classification of all the variables according to their periods. Professor Hough read a paper on Double Star Observations which was in the main a plea for the use of small telescopes for the measurements of wide and easy doubles. Professor Hough claimed that this work could well be done with telescopes of medium apertures and so the large glasses should be left free to devote all their time to work on close and difficult pairs.

On Friday, August 22d sections A. B. C. and D. were invited to hold their sessions at the Rose Polytechnic Institute at Terre Haute. At this meeting Professor Abbe read a paper by Frank H. Bigelow on a Study of Solar Corona. The paper was almost entirely mathematical and contained little of the physical side of the subject. It advanced an hypothesis however, in relation to the spots. If lines normal to tangents to the solar surface be dropped from the extremities of the coronal filiments they will, said Mr. Bigelow, fall within the Sun Spot Zones. From which fact he suggested that there might be a physical connection between the two phenomena. This was suggested as an hypothesis merely without any attempt at proof from observed data.

At the same meeting Mr. Brashear exhibited a negative of a portion of the Ultra Violet end of the spectrum and some photographs of the Moon by direct enlargement. These latter were made by the Henry Brothers and were magnificent specimens of lunar Photography.

At a subsequent meeting Mr. Charles H. Rockwell detailed to us some of his personal experiences on the Eclipse Expedition to Cayenne and exhibited one of the photographs taken there. Mr. Rockwell's time during the eclipse was occupied entirely in photographic work so that he was unable to observe any of the physical phenomena accompanying it.

For the next meeting, to be beld in Washington, the Association elected Professor Hyde of Cincinnati, Ohio, as Vice President and E. D. Preston of Washington, for Secretary. R.

On a New Variable Star near the Cluster 5 M Libræ. About 9^s or 10^s s. p. the cluster 5 M Libræ is a small star which (according to Dr. Copeland) D'Arrest records in his Leipzig observations as of the 11th magnitude. On April 22d, 1890, I estimated it 9.0 magnitude using for comparison the 9.5 star (Argelander) 18′ south of cluster. On May 14th it was 10th magnitude: May 21, 22, 23, 10.2 magnitude; June 6, 10.5; June 9, 19 also 10.5. On May 23 and June 9th I observed this object in Mr. Ingalls' 10-inch refractor. On the latter date it was equal to a star preceding on same parallel and fainter than the north component of a wide 10th magnitude pair just following the cluster. It is double, magnitudes 10 and 12 according to Mr. Espin May 28, lucida white. Subsequently I found an earlier observation with the above mentioned telescope, May 31, 1889 when I noted it as a bright unequal double star the lucida being the brightest of all stars surrounding the cluster.

On the nights, of April 22, May 9, 15 and June 9, Mr. Common obtained photographs of this cluster, two of which were exhibited at the June meeting of the R. A. S. I had the good fortune to be able to examine these plates and found a marked variation of brightness in this particular star and felt justified in calling attention to this object in a note to the Eng. Mech. for June 27, 1890.

Mr. Common has since examined all four plates and finds ample proof of variation. His values are April 22, 9.5; May 9, 11.0; May 15, 9.9; June 9, 10.5, being probably, a variable of some short period. My own telescope was a 4½-inch refractor (dialyte). D. PACKER.

London, July 11, 1890.

BOOK NOTICES.

Text Book of Mechanics, with Numerous Examples, by Thomas Wallace Wright, Professor in Union College. Messrs. D. Van Norstrand and Company, Publishers, 23 Murray and 27 Warren Street, 1890, pp 260, Price not given.

This is a new text book in Mechanics for use in the ordinary college curriculum where the Calculus is regularly taught in the course of pure mathematics. The use of the Calculus is the unusual feature in a book of this grade for the place it is intended to fill. But that the author is right in introducing this method of study for some of the themes of Mechanics there is no question. It is true that all students in the ordinary college courses were requested to know something of the mathematical instrument of investigation in most common and necessary uses in Mechanics, Physics and Astronomy. At the present time, without such knowledge, a student will not be able to follow much very elemental work in these branches that he would otherwise do easily and delightfully.

This book is divided into ten chapters with the following titles. Motion, force and motion, dynamics of a particle, statics of a rigid body, friction, work and energy, kinetics of a rigid body, elastic solids, statics of fluids, kinetics of fluids.

There are some very useful practical examples given in illustration of principles, such as those suggested by the Westinghouse air-break tests of 1887, and the new strong locomotive and other modern mechanisms that might be named. This book is commended to the attention of teachers. It will probably be introduced in Carleton College because the subject matter is good and because the students of all courses of study can use it, having previously pursued the elements of the Differential and the Integral Calculus.

An Introduction to Astronomy, designed as a Text Book for the use of students in College. New York: Charles Collins. The Baker & Taylor Company, Publishers, 740 Broadway. 1890 pp 236

This volume is the third revision of the well-known work on astronomy commonly known as Olmsted's Introduction to Astronomy. It has a history deserving more space than we can now give to its notice. If memory serves us rightly, it was first published in 1844 by Professor Olmsted, who was then in charge of the department of Natural Philosophy and Astronomy of Yale College. In 1861 Julia M. Olmsted made the first revision. After several stereotype editions, in 1883 Professor Snell of Amherst College revised the work for the second time. During this year the third revision has been made by Professor Coffin, Ph. D. of LaFayette College. Considerable changes are made in the text, especially those relating to the work of the spectroscope, and some articles are entirely re-written. Part of the tables are revised and enlarged. We notice that the parallax of 8.″848 is still retained. This value is undoubtedly too large, but there is yet no general agreement as to what numerical value shall take its place. This text-book is the faithful work of a line of excellent scholars for a half century.

Elliptic Functions. An Elementary Text Book for students in Mathematics. By Arthur L. Baker C. E., Ph. D., Professor of Mathematics in the Stevens School of the Stevens Institute of Technology, Hoboken, N. J. Messrs. John Wiley & Sons 53 East Tenth Street, New York City. pp. 118.

It is a source of gratification to us to know that Dr. Baker has recently given his attention to, and written a book much needed. We do not know of another in the English language that fills the place for which it is intended so well. It is true that the student will find abundant material for the study of Elliptic functions in the works of Abel, Euler, Jacobi and Legendre, but these writers are rather obscure and technical for the comfort of the average student, besides the further drawback of being written in a foreign language. In this book the author has taken the wise course of using such methods as are familiar to the ordinary student of the Calculus, and thereby necessarily omitting some parts of some themes to be found in other books. From the brief examination it does not appear however, that the usefulness of the text is impaired, but rather on the

whole, we think vastly improved. The chapters of the text have the following topics: Elliptic functions; periodicity of the functions; Landen's transformation; complete functions; evolution for φ; factorization of elliptic functions; the θ function; the θ and H functions; elliptic integrals of the second order; elliptic integrals of the third order; numerical calculations, q; numerical calculations, K; numerical calculations, u; numerical calculations, φ; numerical calculations, $E\ (k.\ \varphi)$; applications. We shall take pleasure in reading this book with our students in post-graduate studies in mathematics, as the theme is reached in our regular study.

A Handbook of Descriptive and Practical Astronomy, by George F. Chambers, III: The Starry Heavens, Fourth Edition. Oxford: At the Clarendon Press, 1890, pp. 337.

We are pleased to see the completion of the revision of this excellent Handbook of Astronomy. In our judgment Professor Chambers has done a work, in this direction, of unparalleled usefulness, and he will receive the hearty and deserved commendation of astronomers everywhere for it.

This part is presented in fourteen chapters accompanied by eighty-two illustrations, some of which are printed in colors.

The order of topics is as follows: Stars in general, Double stars, Variable stars, Clusters and Nebulæ, Variable Nebulæ, the Milky Way, the Constellations, Useful Catalogue of Naked-eye stars, On Finding the stars, a Catalogue of Celestial Objects, a Catalogue of Variable stars, a Catalogue of Red stars, a Catalogue of Binary stars, a Catalogue of New stars, index to part III. and general index to whole work.

We are agreeably surprised to notice that this part contains references to late work in so full a way. Recent progress in astronomy has been so great in many ways that a single volume, or even three of convenient size could not contain all that might be well and usefully said. We have space only to mention a few of these points, such as the comparison drawn by Mr. Monck of the results of stellar photometry by Pritchard and Pickering; generalizations from Struve's catalogue of double-stars and the conclusions drawn by Niesten. Chandler's generalization on the colors and periods of variable stars, historical statement relating to the aberration of Nebulæ and Clusters, the catalogue of the naked-eye star and the remarks accompanying it, in which we notice what is said on pages 120 and 121 regarding the work of Dr. Gould, entitled *Uranometria Argentina* and the *Harvard Photometry*, by Professor Pickering. While these works are distinctly and rightly commended, the author's criticisms on some features in each is severe, certainly to the limit of justice, and, we believe not intentionally beyond that point. It is not, we think, a piece of scolding which seems to be rather fashionable among some of our English writers now-a-days; and if it were, those two noble men most interested ought to be happy in view of the small charges against them.

It will be of some interest to the author to know that a considerable number of inquiries have been made at this office concerning the last edition of his work, and that some of the high schools of the leading cities of this country, at our suggestion, have purchased the entire work as reference books for the teachers and students in astronomy.

Elements of the Differential and Integral Calculus, Method of Rates by Arthur Sherburne Hardy, Ph. D., Professor of Mathematics in Dartmouth College. Boston, Mass., Messrs. Ginn & Co., publishers. 1890, pp. 239.

It is an interesting and significant sign of the times that the younger mathematicians and teachers in the branches of the so-called higher mathematics, feel called upon to write so many books on the elements of the calculus. The effect of this can but be good, and we are heartily glad to see it.

The first and most important new feature in this book is the elemental basis of its analysis. It is neither that of limits nor infinitesimals, but a method of rates. In his teaching the author has found that this method proves more satisfactory than any other for the first presentation of the object and scope of the Calculus. We say this is a new feature, or a new way of unfolding the elements of the science, and yet we do not forget the work done by Professor E. Loomis, of Yale College, a quarter of a century ago in this same direction, yet, of course not as complete and full as in this work. On the supposition of the change of rate of the variable function all the elementary rules are formed, and the troublesome question of orders of quantities is not raised, and fortunately, the student is given a start and some basis for independent thinking before he is required to form his opinions, or express them, on theoretical points which divide mathematicians as to best methods of presentation, if not in regard to the fundamental facts of the science. This point we like. It is the strong one in favor of the method of rates, and in our judgment gives it clearly the preference above all others.

The first part of this book is devoted to the Differential Calculus which covers 164 pages. The second part treats of the Integral Calculus. The range of the work is equal to that of the best books prepared for the courses of the modern college or scientific school. Its examples for practice are not as numerous as those of Bowser, but they are better graded than those of Olney. The arrangement of the matter on the page and the variety of type chosen are features that teachers will notice and commend, and they are equally aids to the student whether he knows it or not. We do not know of a book on the elements of the Calculus that impresses us more favorably on the first brief examination.

Books Received.

New Light from Old Eclipses, by Wm. W. Page, C. B. Barnes Publishing Co., St. Louis, Mo.

One Life, One Law, by Mrs. Myron Reed. Jno. W. Lovell & Company, Publishers, New York.

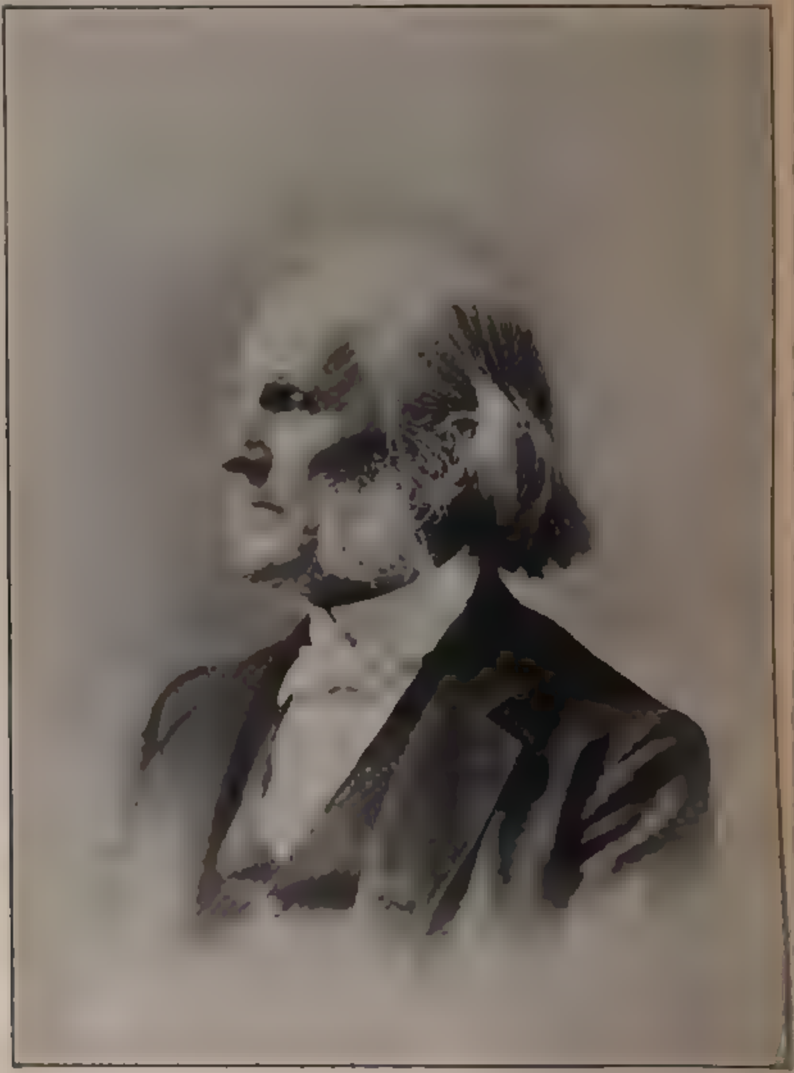
The Pathway of the Spirit, by John H. Dewey, M. D., Frank F. Lovell & Company, Publishers, New York.

Plane and Solid Geometry, by E. A. Bowser, L. L. D., D. Van Norstrand Company, Publishers, New York.

College Algebra, by Webster Wells, S. B., Messrs Leach, Sherwell & Sanborn, Publishers, Boston and New York.

Father Perry, The Jesuit Astronomer, by Aloysiaus L. Corlie, S. J., Published by the Catholic Truth Society, London.

Manual of Instruments for American Engineering and Surveying. Published by W. and L. E. Gurley, Troy, N. Y.



CHESTER SMITH LYMAN

THE SIDEREAL MESSENGER

CONDUCTED BY WM. ...

DIRECTOR OF CARLETON COLLEGE OBS...

VOL. 9, NO. 9. NOVEMBER, 18...

THREE INTERESTING B...

NEWTON M...

FOR THE MESSENGER

Some years ago I presented in the Mes... of the star 61 Cygni which attracted a little ... is mentioned for all it is worth in Miss Clerke... Progress of Astronomy in the Nineteenth C... leisure to review that labor with the aid of ... tions having come to me I have given th... thorough a study as I know how, ... gether with some work on two other ...rs, I ... place on record in these same columns.

The curve described by the ... motion of 61 ... through which no end of different ellipses may be ... pass with nearly equal satisfaction. Which of the... st to the true orbit must be determined by ... tions. The first question is as to the probability of ... having passed its periastion during the time it has be... der observation. This is a point I did ... sufficiently ... sider in my first work. The constant ... stance of ... tar and its increasingly slow motion ... that it ... been moving for the last hundred years to ... part of its orbit, and that the apparent ... drawn with its center between the curve ... and the principal star. Such an ellipse ma... shown on the following page (Fig. 1), angles ... as in my former work. This I drew large with ... ellipsograph and worked out with care.* ...

* The elements obtained may be added merely as ma...

e	0.144	γ	57° 1...
π	294° 40	Ω	157° 15′
P	612.7 ...rs.	T	216...

It is needless to say that the drawings in this article ... of illustration.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, NO. 9. NOVEMBER, 1890. WHOLE NO. 89

THREE INTERESTING BINARIES.

NEWTON M. MANN.

For THE MESSENGER.

Some years ago I presented in the MESSENGER a discussion of the star 61 Cygni which attracted a little attention, and is mentioned for all it is worth in Miss Clerke's book on the Progress of Astronomy in the Nineteenth Century. The leisure to review that labor with the aid of later observations having come to me, I have given the subject as thorough a study as I know how, the result of which, together with some work on two other stars, I am glad to place on record in these same columns.

The curve described by the companion of 61 Cygni is one through which no end of different ellipses may be made to pass with nearly equal satisfaction. Which of these is nearest to the true orbit must be determined by other considerations. The first question is as to the probability of the star having passed its periastion during the time it has been under observation. This is a point I did not sufficiently consider in my first work. The considerable distance of this star and its increasingly slow motion indicate that it has been moving for the last hundred years toward the remotest part of its orbit, and that the apparent ellipse should be drawn with its center between the curve already described and the principal star. Such an ellipse may be drawn as shown on the following page (Fig. 1), angles and distances as in my former work. This I drew large with an excellent ellipsograph and worked out with care.* A comparison

* The elements obtained may be added merely as matter of curiosity.

ε	0.144	γ	57° 15′
π	294° 40	☊	157° 15′
P	612.7 years.	T	2169.63

It is needless to say that the drawings in this article are only for purpose of illustration.

with the long list of observations gives nothing to complain of. One thing only leads me to suspect that it is not the orbit nor anything like it. These objects are not likely to show so small an eccentricity—0.144. Other efforts were then made—a score or more—all widely different, but preserving substantially the same curve required by the observations. It is hard to choose, but that which on the whole seemed to me to stand the best chance, is given in miniature

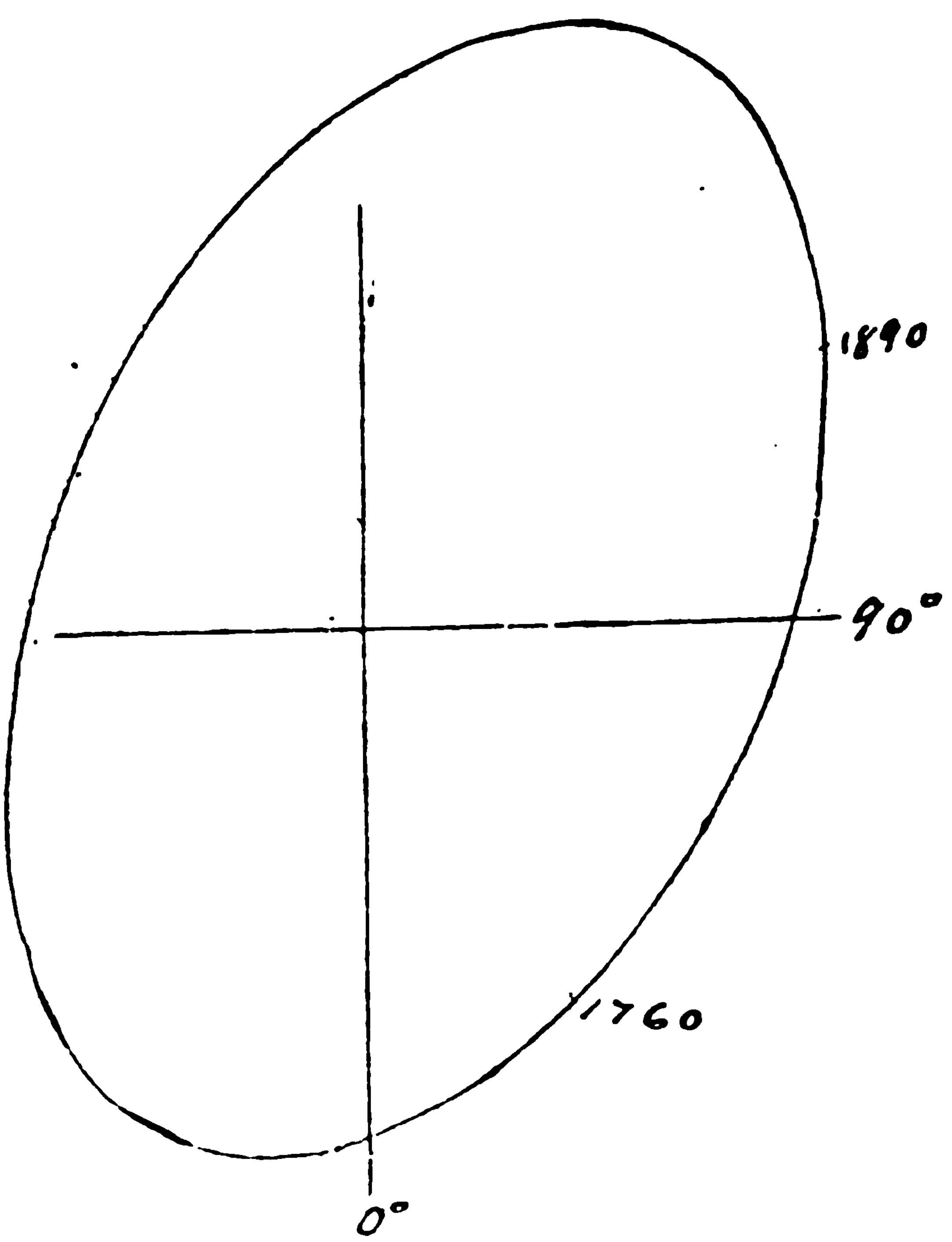


FIG. 1.

in Fig. 2. This, it will be observed from the position of the principal star, is a sufficiently eccentric orbit. It provides for a yet long-continued slow motion while reducing the period much below what has been heretofore calculated. These are the elements:

ε	0.529	γ	62° 17′
☊	170°	π	303°
P	462 years.	T	1661.42
a	23″.90		

From what has been said it will be seen that this, or any other determination, can be only tentative; but after a good deal of labor I submit the following as perhaps the best that can be done at present. On this basis, taking the parallax at 0.″55, the mass of the system is 1.45 times that of the sun.*

We pass now to a more brilliant and otherwise hardly less interesting object. Castor has pretty effectually set aside

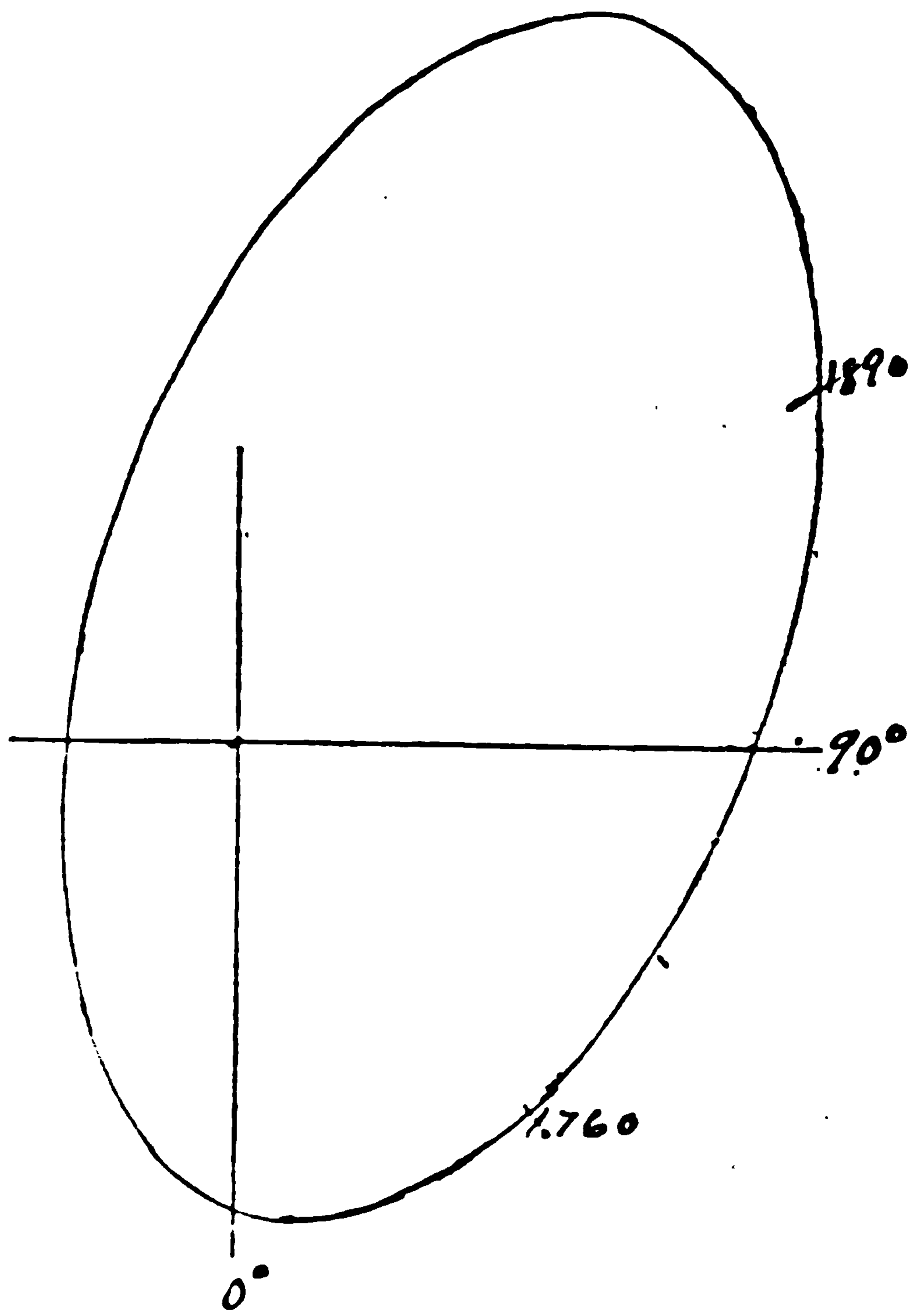


FIG. 2.—61 CYGNI.

the orbit that Wilson gave it in 1877, the delineation of which in the "Handbook of Double-Stars" has afforded many of us amateurs so much delight. Recent observations make it almost certain that he and others erred in this case,

* I was once disposed to think that the relative mass of the components of a binary system might be indicated by systematic discrepancies between measures of distances at different epochs and the distance computed from angular displacement. It is a delusion.

as I did years ago with 61 Cygni, in supposing the periastron to lie within the curve described since observations commenced. In fact the two stars present a remarkably similar situation, both having shown for a long time an increasingly slow motion, indicating in both an approach to the point of greatest distance. In the case of Castor that point is now very surely passed, the observations of the last

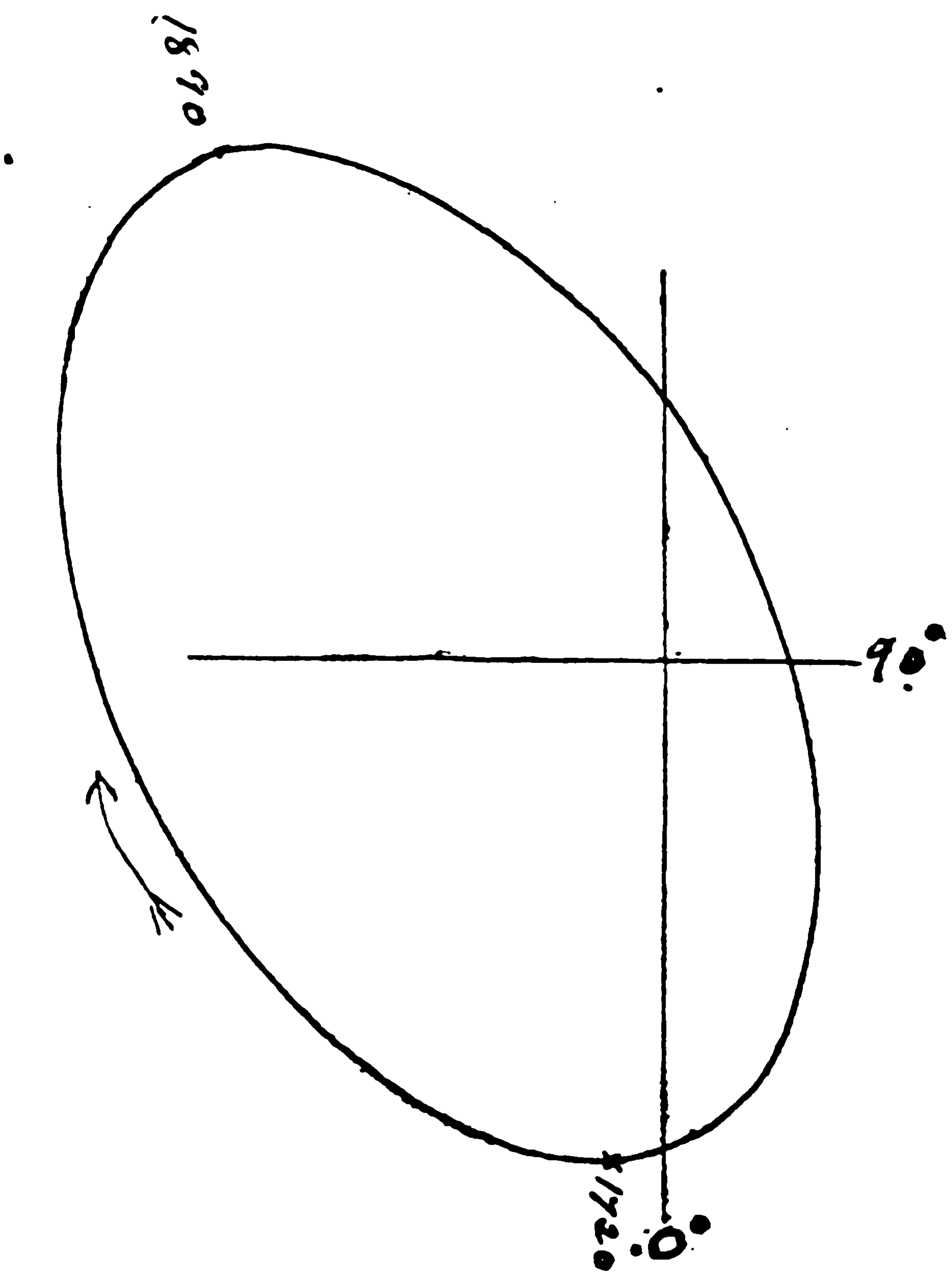


FIG. 3.—CASTOR.

two years showing a sensible decrease of distance. This is a state of things not provided for in Wilson's orbit until after the year 2147, and it is just the clew needed for something like a definite determination of the elements of this gorgeous system.

Two points now apparent about Castor ought to have

been considered probable before—first, that the companion has been seen only in the remoter part of its orbit, and second, that the orbit is of high eccentricity, this latter on general grounds. When we recall that the parallax of this star is almost, or quite, inappreciable, the enormous distance represented by five seconds of arc ought, it would seem, to have suggested anything but a periastron.* When in 1949 the real periastron is reached the two stars will be less than one second apart. I take pleasure in submitting a miniature representation of this orbit according to my last work. The reader will observe that the decrease of distance since 1886 makes it certain that this cannot be far wrong.

This gives elements as follows:

ε	0.653
γ	63°
π	90°
☊	28° 40′
λ	75° 53′
P	265.7 years.
T	1949
α	5″.54

As much attention is likely to be drawn to this star in the next few years I give the starting points of my calculation. On the strength of the earliest observations, which are discordant, I assume the position angle in 1722.42 to have been 355°. As Herschel's measurement in 1783.63 made it 293°.6, and again in 1791.15 so much as 293°.5, I take the mean and put it (corrected to Eq. 1890) at 293°.5 in 1785.45. Then Herschel's observation, 1802.06, is accepted as exact, also South's in 1825.24, Dawes' in 1833.14, Smith's 1843.13, Bond's 1848.30, O. Struve's 1854.94, Main's 1862.31, Wilson and Seabrook's 1872.86, Dembowski's 1875.25, and one of 1889 from the unpublished work of a distinguished astronomer whose name I am not at liberty to give. The curve that runs through these points keeps well in the mean of all the observations, some 230 in number, that I have before me. The star will be slow for some time yet, and we shall hardly live to see how it accords with the calculation; but here are its places on toward the middle of the next century:

* It is interesting to note that the earlier efforts to determine this orbit now appear the best. Compare Madler's elements, 1842, with the numerous attempts subsequently published, Handbook of Double-stars, pp. 239-240.

Date.	Position Angle.	Distance.
1898.70	225°	
1908.70	220°	5″.14
1917.52	215	
1924.90	210	4″.30
1930.70	205	
1935.05	200	3″.26
1938.27	195	
1940.64	190	2″.41
1942.39	185	
1943.71	180	1″.82

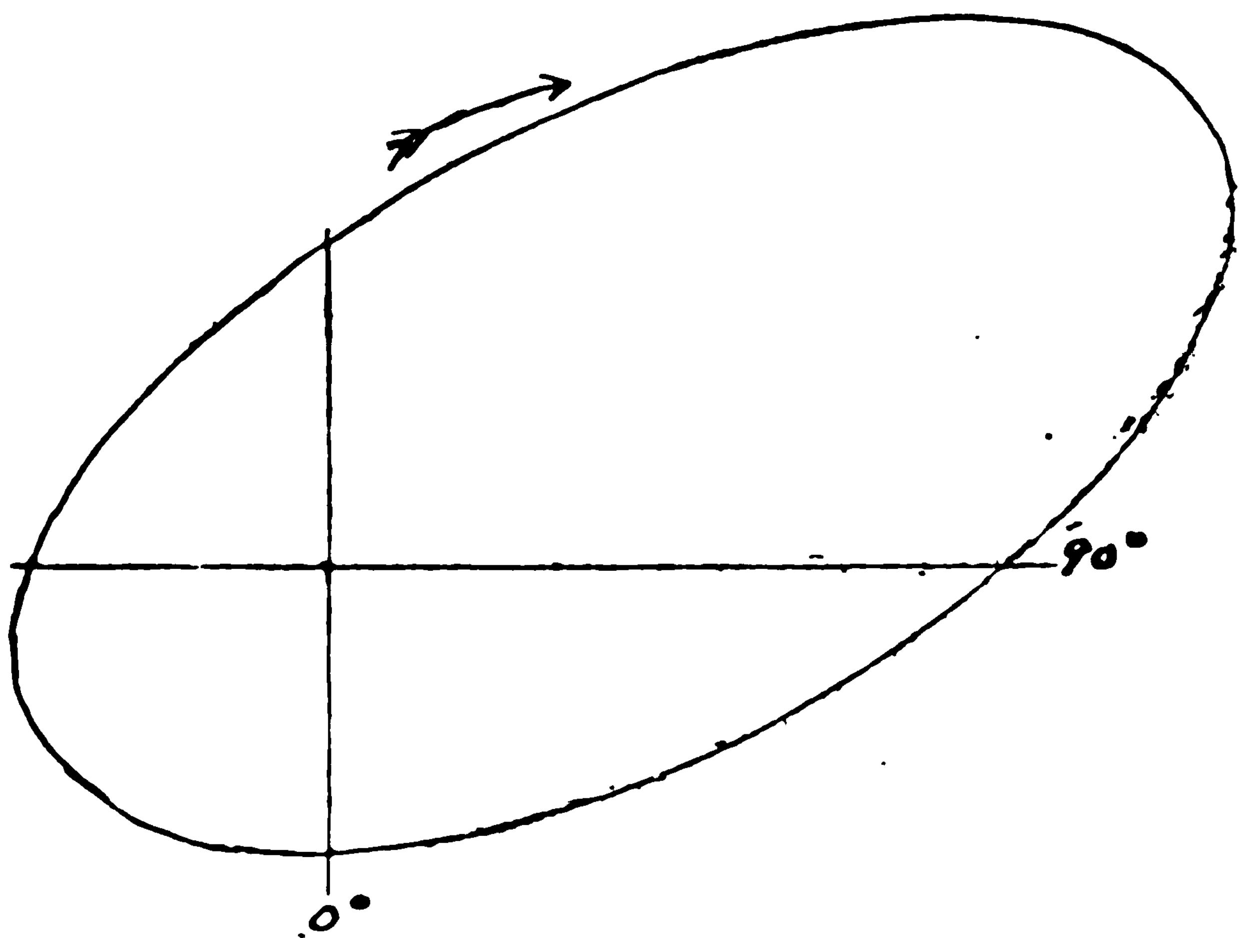
About ten years ago I read a paper on the orbit of 70 Ophiuchi before the Academy of Science in Rochester, N. Y. The elements I then obtained were:

T	1806.63
ω	178°
Ω	118° 36′
γ	55° 8′
ε	0.5085
α	4″.41
P	87.40 years.

Since then the star has passed through 90° of its orbit. I have been interested, therefore, in reviewing that work, which I have done in as thorough a manner as possible. This is a star that has just made an entire revolution since the first good observation was made. One would think therefore that it might be easy to reduce. But a closed orbit has difficulties of its own. It restricts the liberty of conjecture by which one leaps over many obstacles. It leaves no back alley into which to pitch a surplus of time or space. Corrections and re-adjustments become delicate and difficult. At least so I have found it, and I should be almost ashamed to say how long I have worked on this thing. But there are always shorter cuts to an end that one sees after he gets there. The story therefore can be made brief.

Herschel in 1802.25 found the angle of position (corrected to Eq. 1890) 335°.6. The pair showed the same angle in 1890.37, as nearly as I can judge from the rather incongruous observations at hand of recent date. This makes the period 88.12 years. With a fixed ratio of square millimeters to years we assume what must be the contents of the ellipse representing the apparent orbit. Its eccentricity then remains to be found, and the direction of its node by a series of comparisons and approximations requiring some patience. Finally the ellipsograph must be so set that it will

meet all three of these requirements by describing a medial line through the points representing the observations of a century and enclosing the fixed number of square millimeters equivalent to 88.12 years. Add to this that the line must not be heavier than a hair, and that the measurements must be made under a strong lens. Progressed so far, Herschel's observation of 1804.41 comes in somewhat to modify the calculation, as it seems to require a period of a little less than 88 years. Between the two the best seems to be to put it at 88.04 years. The motion of this star has been so rapid of late that the reckoning of time has to be carried to the third place of decimals. A rude little diagram gives but a poor idea of this beautiful object. The orbit differs from the two others I have discussed in having the line of nodes nearly coincident with the projection of the major axis, so that the principal star appears less distorted from the focus by the inclination of the orbit.



As will be seen by a comparison of results, my present work is only a refinement upon that performed ten years ago. Some further slight changes may be made necessary by the observations of the next ten years, but these elements, cannot be much in error:

a	4″.45	e	0.4994
Ω	120° 48′	π	295° 44′
γ	57°	P	88.04 years.
T	1895.28		

This determination compared with the observations accords excellently well back to 1825, when the plus residues (observed, minus computed angle) begin to be slightly in excess. But the observations are few and the excess is not more than 1°, always leaving out of account Herschel's two first, which contradict each other. The first of these, 90°, 1779.76, is short 8°.4, and is probably an error of record for 98° or possibly 100°.

I append an ephemeris:

Date	Position Angle	Distance ″	Remarks
1890.990	330	2.00	
1891 560	325	2 04	
1892 160	320	2.09	
1892.777	315	2.12	
1893.426	310	2.16	
1894 072	305	2.16	
1894 761	300	2.16	
1895.280	295 73	2.13	Periastron passage
1896 609	285	2.10	
1897 697	275	1.91	
1898 652	265	1 78	
1899.482	255	1.69	
1900 237	245	1.62	
1900 941	235	1.58	
1901.350	229	1.57	Min. apparent distance

TENERIFFE, ALTA VISTA, TEYDE.

D W EDGECOMB

FOR THE MESSENGER

Thirty-four years ago the first experiment with telescopes at a high altitude was made at Teneriffe by Piazzi Smyth far up on the lava-covered side of Teyde, and the account of his residence and successful observations above the clouds forms a part of every astronomical library. Since that time, until quite lately, the island has been almost as little visited by travelers as before, and it is still quite out of the line of American travel.

Within three or four years, however, it has been growing as an English watering place, and every winter brings an increasing number who seek to avoid the fogs and storms of England.

It was many years since I had read "An Astronomer's Experiment," but the pleasure it had given me was still fresh in my memory; and it was therefore, with far more than the

interest of the ordinary tourist, that on the morning of the fifth day from the English coast, from the deck of an Australian steamer, touching at the Canaries, I was able to trace, far ahead and high amid the clouds, the dim outline of Teneriffe. We *may* see the peak, said the captain, but as it is more than thirty miles away, nearly at the other end of the island, and generally either covered with clouds, or hidden by those that cover the intervening mountains, it is only occasionally seen as we approach from this side. I was fortunate enough, however, before the day was over to see its snowy cone capping the grand mountain mass of which the whole island consists, delicate in the distance, and only suggesting its great height by the angle which the direction of its summit forms with the surface of the sea.

Approaching the shore, under the swift march of the steamer, the interest increases almost from moment to moment, as the massive features of the island are revealed. Vast rocky masses, of mingled green, brown, red and yellow, rise in precipitous cliffs from the sea, mountain ridges with their crests indented and broken, with cone and battlement and pinnacle, standing in relief against the sky, while many a deep and shadowy gorge came down to the sea between them, passed us as we approached our landing place, the harbor of Santa Cruz, the capital of the Canaries. Hardly can it be called a harbor but an anchoring place, sheltered in part from the trade wind and the swell of the Atlantic, by the mountainous Eastern end of the island, along which, at a mile or so distant, we had been sailing. And under the lee of these mountains also, we have come to realize, almost suddenly, as it were, by the absence of the sea breeze, and the cessation of that caused by the motion of the steamer, that we were in another climate, for a tropical sun shone down upon deck as the ship swung to her anchor, and the white-washed houses of the town on shore before us glowed and glistened in the summer light.

Landing, or rather tumbling ashore, for it was a tumbling swell that still came in against the mole from the Atlantic, we found ourselves in the midst of men and women in tropical dress, children in tropical undress, donkeys with the most overgrown loads, other officials in bright uniform bearing equally overgrown loads—of importance,—baskets of oran-

ges, canary birds in cages, golden sunshine, and withal, an immense quantity of the Spanish language. Following however, a little streamlet of English which proceeded from the mouth of the hotel guide, we passed through the streets, stopping only to gaze at the solemn, deliberate tread of three camels, further reminding us that we were geographically in Africa, and at the parallel of the great desert.

Our destination is the Grand Hotel at Orotava;—where is the place on this side the Atlantic without its English "Grand Hotel"?—under the shadow of the peak, and, say all, where the climate more than justifies the ancient titles given to the islands, the "Gardens of Hesperides," the "Isles of the Blessed." It is a ride of about twenty-five miles and certainly it would be difficult to imagine a more beautiful one. The road rises fifteen hundred feet above the sea, passes through a dreary town, Laguna, at that height, but afterwards along the northern side of the island presenting a series of the grandest views of a land sloping from cloud to sea. Everywhere by the roadside, the geranium grows in weedy profusion, covered with scarlet blossoms, while petunias, pinks, violets, mignonette, and all our familiar plants, greet us from out the little gardens; and all in blossom, the climate making contemporaries of them all. From among these the little birds of Canary greeted us with chirp and twitter, making a June day of the first of February. Most striking of all are the palm and orange trees, the "waving plumes" of the one and the golden fruit of the other recalling to mind the half forgotten descriptions of Humboldt and Smyth.

And always as we approach, the trade-wind clouds open and close, everchanging in height and depth and form and color, displaying and again concealing, on one side far off below, the ocean, and far above on the other, the form of their king, the high and mighty peak.

From one side finally, at an elevation above it of a thousand feet, we look down into the "Valley of Orotava." A grand amphitheater it is, with mountains on three sides and the sea on the other. What could have been the cause and what the manner of such a subsidence? For the slope along which we have been advancing extends not to the sea level, but along the sea front ends in precipitous cliffs a thousand

feet in height. A section of this elevated slope, six miles or more in width, has sunken, gradually or suddenly, at some time, until its front is level with the sea, while its opposite side is still the mountain ridge. The sides of the valley then present sections, in some places nearly two thousand feet in thickness, of the higher portions of the island. Looking across the broad chasm, the mountains on the opposite side are blue with distance; towns and small clusters of houses lie scattered over the valley, and a little beyond the opposite and highest corner rises high the snowy peak.

Smyth had much to say of the clouds, and describes a curious and furious battle between the forces of the opposing trades. It would be indeed impossible to give even the faintest idea of the pictures presented by these trade-wind clouds seen during a residence of a few weeks at the sea level in the valley. Generally the mountains are covered, and a broad canopy extends over the valley and a little way out to sea; but at morning and evening they often break, lift and are dissipated, revealing the crests, the slopes and gorges that form the sides of the vast amphitheater, together with the crowning peak, and exciting more and more admiration each day, at the grand scale on which the whole is built.

So gradual is the elevation of the broad inclined plain from the sea that as one looks up the valley it is difficult to believe that the culminating crest is from six to seven thousand feet high, or that the clouds that meet and rest against the cultivated fields half way up the easy slope, are as high as those overhead.

In the early morning and in the afternoon, the lower air is clear and tranquil and affords beautiful pictures of distant objects in the telescope. Natural features, the curves in the sides of the high bluffs along the sea-front or the great sectional walls over-looking the valley, the homes of the ancient Guanches, and the houses and villages far away on the mountain slopes are so well defined that they appear to be but at a small part of their real distance, and the power of the telescope seems doubled. But the hope thereby raised that the evenings will be found also good for telescopic vision is rudely shattered. To the naked eye indeed, the evenings when clear from clouds are glorious in the extreme.

The concave sky seems lowered and the stars are near and brilliant. The scene is made more beautiful by the fact that the heavens are equally dark and the stars equally bright to the very crest of the mountains that form the southern horizon. I have more than once placed the peak in the field of view and watched the occultation of stars at various points along the cone, and their emersions on the western side. Generally the disappearance was sudden, almost like a lunar occultation, but sometimes, probably when the rays encountered a warm breath from the mountains, they performed strange gymnastics for a short period before dodging behind the cone.

To northern eye on these clear nights the region Argo, extending to the south and east of Canis Major is most resplendent with stars, while Sirius, raised by twenty degrees above its position as we are accustomed to see it, and supported from below by that grand field of thickly clustering stars of Argo, seems more than ever worthy of its title of Leader of the starry host.

But how they all twinkle, and how suspiciously large they look for there are two opposing currents of air in motion over the valley, and these are of different temperatures, so that the rays are sadly demoralized when they reach the eye What an image, therefore, one gets in the telescope! A grove of chimneys could not work more mischief; and after many experiments at different hours on the clearest nights, I abandoned the telescope in disgust. All this might have been known *a priori* from the conditions so well studied and described by Smyth, but who would have believed the result would have been so invariable?

Experiments on the peak itself are hardly practicable before the middle of June, for it is too near the line of perpetual snow, and too liable to savage storms, and as I could not well stay so long, I must content myself with a pilgrim's visit to Alta Vista, and the Crater. The height is twelve thousand two hundred feet, and as the work begins at the sea level, there is no discount or reduction to the climber, from the total elevation to be overcome. One can ride to Alta Vista and the way is probably no better, if no worse, than when Smyth's cavalcade passed over it. It requires the same good qualities in horse or mule

and the same patience and endurance in the rider now as it did then. No one will question a single foot of the reputed height that has made the journey.

Passing up the valley the marks and evidences of volcanic action abound on every hand. They appear in the parasitic cones or craters that form prominent features of the broad plain itself, in the confused lava rocks that cover the surface, and the exposed edges of lava sheets in the sides of the gorges or "barancos;" and most and grandest of all, when one passes out above the misty cloud into the upper sunshine and finds himself in the "Canadas," the pumice strewn floor of the great ancient crater, eight miles in diameter with its encircling mountain walls and from the center of which rises before him the enormous mass of the central peak and its crowning "white-lipped" cone. No observer of lunar scenery can help exclaiming, surely this is the moon. Masses of red lava protrude from the fine pumice floor in broken heaps, and although confusing at first, a little observation shows the arrangement of radiating lines from the central cone. But it is from the peak itself that the lunar likeness is most striking.

For as one approaches, his eyes are always turning towards the summit so clearly defined against the sky, and from this point it is easy to see the continually recurring puffs of white vapor which are forced above the apparently sharp pointed top of the still active volcano.

Without the corrective of an actual knowledge of the angle it is easy to over-estimate the degree of inclination of a mountain like the cone of Teyde. It is about thirty degrees, but seems nearer forty, as the sure-footed mule of the islands zig-zags up the cindery side. The path lies between two enormous streams of black lava—and how black and shuddering those torrents are—which converge as you rise until they meet at Alta Vista. One hardly wonders at the "impossible" of the Spaniards when they looked at the ponderous mounting of Smyth's equatorial and heard him calmly propose to erect it at Alta Vista. For my "mulo" had surely used his last reserve of force, when he bore me forward upon the bit of level ground which forms the historic plateau and invited me to dismount by the side of the half ruined walls which marked the site of the "Astronomer's experiment."

The walls are quite well enough preserved to show fully the form and manner of the enclosure, and after visiting each apartment I sat upon a corner stone and looked up at the heavens. I had watched the sun as it passed to its setting behind the peak, and the earth's shadow as it rose distinct in the eastern heavens, as well as the rising of the moon out of the ocean from a point a thousand feet below. Now, at three o'clock in the morning, Jupiter was high in the heavens, one of the objects Smyth especially observed. The moon, Mars and Antares formed a triangle within a small area in Scorpio, while that whole constellation was spread upon the sky at an altitude that showed its beauties and suggestive form in a manner most striking and impressive to the northern eye.

An hour and a half later and I had climbed over the vast masses of black lava, and up the loose cindery side of the final cone, which make up the two thousand feet of height above Alta Vista, and stepped over the narrow brim into the white smoking crater. One is willing to wait a little before taking anything like a leisurely look from the pinnacle on which he finds himself standing, for it is a biting wind, "a nipping and an eager air," that sweeps through that rarified region, and there is an inviting warmth within. A little below the edge therefore, and sheltered by it, I drew close to a great opening through which came hot breaths from —somewhere,—sulphur laden but not suffocating.

The crater is about two hundred and fifty feet in diameter, and its concave floor sinks to a depth of sixty or seventy feet. The sulphur breath of the volcano has whitened the whole interior and the exterior also for a short distance from the top, which gives it the white-lipped appearance from a distance. Around the many escape pipes, through which the steaming fumes come, in some cases with a deep but not heavy roar, fine sulphur crystals are forming and the visitor may gather some which will be made for him "while he waits."

Looking across the crater, at the moon and Mars and the stars in their neighborhood, what strange contortions did the rising puffs and little clouds of heated vapor cause them to make. They danced, expanded, changed form and color in a manner most kaleidoscopic. Now looking to the

east, long radiating lines of vivid light strike upwards against the light clouds that float near the horizon, and make a golden pathway for the sun. Downwards, far, far below was spread, from beyond the great crater walls, the white, billowy surface of the clouds that covered the low valley of Orotava. Beyond these and on every side what a delicate azure is the ocean; how much more insubstantial it appears than the clouds; how softly upon its ethereal surface rest the other islands of the archipelago, one wrapped to its mountain summits in snowy cloud, seems to float upon the sea like a mass of softest down; another, cloudless, presents varied shades of greenish brown in the morning light, while the outline of its shore is marked upon the blue by a delicate line of white, the surf; and a third has its crests encircled by a broad thin horizontal ring of cloud. What a lovely object the earth must be if observed from a sufficient distance.

As the sun comes up from the great desert the shadow of the peak rises against the western sky. It is at this time that the lunar crater immediately below is seen in its most striking aspect. Except that the central peak is much higher than the walls, which rarely happens in the moon, one cannot avoid the conviction that the view is just what would be had from many a central peak there familiar to the telescopist. The old wall is not complete, but quite enough remains to show the part it has taken in the history of the volcano. On the eastern and south-eastern side a section throws its shadow over the floor of the crater, while the eastern or sunward side of the peak and the interior slopes and precipices of the southwestern wall, shine brightly in the light of the rising sun. The small craters and masses of lava which cover the floor are brought into high but temporary prominence by thin dark shadows. Radiating lines of red lava cover one part reaching out to the foot of the crater wall, while a shower of pumice has at some time been thrown over another part forming a smooth floor through which the points and ridges of the lava streams project. Guajara, the highest point of the wall on the south, has plainly to be seen on its rounded top the heap of stones piled by Smyth for the first part of the "Experiment." In every direction beyond the walls of the great crater can be seen the parasitic cones that at different times

have become the vents for the volcanic forces below, and these add familiar features to the lunar likeness.

It is well worth the effort to raise one's self, for once, as far above the clouds as one lives ordinarily below them, and learn how much more beautiful they may appear from above than from below, and for a telescopist there is no mountain like Teyde, for he may almost feel that he has been to the moon.

Santa Cruz, Teneriffe, May 19, 1890.

CHESTER SMITH LYMAN.*

Chester Smith Lyman was born Jan. 13, 1814, at Manchester, Conn., being the eighth lineal descendant of Richard Lyman who landed in America in a company of Puritans in the severe winter of 1635.

In boyhood Professor Lyman had the advantages of a common country school while working at intervals on a farm. At the age of nine years he showed unusual mechanical ingenuity in making toys, windmills, waterwheels, etc., as well as a great interest in Astronomy and the kindred sciences. Very few books of any kind were within his reach and those of a scientific character were even more scarce than others. He however, gained possession of one on natural philosophy, Gibson's Surveying and Bowditch's Navigation. From these books he learned the nature of lenses, and without a teacher, the rudiments of geometry and trigonometry and some knowledge of surveying and navigation. He extemporized a telescope for himself from a small burning glass, a yard stick and his mother's spectacles, and, in later life he said: "I can never forget the delight with which I turned this upon the Pleiades," and for the first time saw this cluster expanded into a large number of brighter stars.

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* The facts for the following brief sketch of the life and work of the late Professor Chester Smith Lyman are mainly taken from a well written article which appeared in the November number of the "Popular Science Monthly" for 1889. The frontispiece was made from a photograph kindly furnished bp Mary F. Lyman.

At thirteen he eagerly read Ferguson's Astronomy and articles on Optics and Astronomy in the Edinburg Encyclopedia. From thirteen to sixteen he spent most of his spare time in his father's tool shop constructing astronomical and other instruments from the diagrams of his few much prized books, such as a sextant, quadrant, celestial globe, orrery, eclipsareon, solar microscope and a Herschelian telescope four feet long which enabled him to see Jupiter's satellites and belts, Saturn's rings, the moon, and other celestial objects. He computed all the eclipses for fifteen years to come and made almanacs for 1830 and 1831. In order to give the places of the planets in these almanacs (never having seen a nautical almanac or astronomical tables of planets) he made rough tables for himself computing them from the elements of the planet's orbits as given in his book on natural philosophy. At the age of fourteen came his first experience in the study of the Latin, from which he derived the life-long conviction that the ordinary methods of teaching the classics consumes fully one-half more time than is necessary to accomplish the same results.

Two or three years later, leading business men of Manchester became interested in the mechanical and scientific pursuits of Mr. Lyman, and sought appointment for him to a cadetship at West Point. Pending this, he became interested in religious matters, and he determined instead of entering the military profession to pursue a college course of study and become a minister. To carry out this plan, he attended the Ellington school in June, 1832, a prominent preparatory school in New England, and fitted for college in twelve months' time, and in 1833 he entered Yale College without conditions. During his Junior year, Mr. Lyman was one of the originators and editors of the Yale Literary Magazine. In addition to his regular studies, in which he took high rank, he was assistant to the Professor in Natural Philosophy and gave some attention to observations in progress at the Yale Observatory.

On graduating in 1837, he was offered several eligible positions, such as a professorship in a University, a place in the Wilkes' Exploring Expedition, an examinership in the Patent Office, etc., but he accepted for two years the superintendency of Ellington School, after which he attended

Yale and Union Theological Seminaries, then he occupied a short pastorate at the First Church in New Britain, Connecticut. Health failing, he took a sea voyage, and after seven and a half months he reached the Sandwich Islands, where he remained a little more than one year. While at this place he visited and mapped the volcanic crater of Kilauea, afterwards fully described in the "American Journal of Science" The great rainfall at Hawaii led Mr. Lyman to construct an ingenious, self-registering rain gauge, so that an accurate measure of the total annual rainfall could be known It was found to be over ten feet. While at this place he also taught the Royal School, for a few months, having among his pupils four young chiefs and a young woman who later was known as Queen Emma The young chiefs also all subsequently occupied the Hawaiian throne

In July, 1846, Mr Lyman returned to California, and being a practical surveyor soon found employment in San Francisco, just then newly laid out, and not having buildings enough anywhere to show the direction of any street but that of Montgomery. He was also employed in various parts of California in surveying ranches and towns, especially in the region southward towards San José which place he was employed to resurvey. He made the original survey of the famous New Almaden quicksilver mine, probably the richest mine of the kind in the world.

In May 1847 gold was discovered at Sutter's Mill on the American river, about one hundred and fifty miles to the north. Soon Professor Lyman and his surveying party visited that point, and the letters which he wrote to the Eastern papers concerning the gold discovery were among the first authentic accounts published, and his articles awakened very unusual interest. He did not stay long in this region; his health being restored he returned to New Haven in 1850, and in June was married to Miss Delia W Wood, daughter of Hon. Joseph Wood. He settled permanently in New Haven, and again engaged in literary and scientific work, part of which was the preparation of definitions of scientific words for the new editions of Webster's Dictionary In 1859 he became Professor of Industrial Mechanics and Physics in Yale College, taking an active part in the organization of the Sheffield Scientific school in which he taught Astronomy.

In 1871 his chair in this school was changed to astronomy and physics. In 1884, on account of his impaired health, he resigned the chair of physics, but still retained the Sheffield Professorship of Astronomy from the organization of the school in 1860.

Professor Lyman was the original inventor of the combined transit instrument and zenith telescope for determining latitude by the Talcott method. It was constructed by him in 1852–53, and was described in the American Journal of Science. This was ten years before the account of a like instrument appeared by Davidson.

As we have before said, Professor Lyman was actively interested in the establishment of Yale Observatory, and was one of its board of managers. It will be easily remembered by all readers, too, that he was the first to observe the delicate ring of light around Venus at inferior conjunction in December, 1866, and also before and after the transit of Venus in 1874. As a thorough scholar, a successful instructor and an original investigator, Professor Lyman was eminent, and well and widely known in the literary and scientific circles of the world.

MOTIONS OF PLANETARY NEBULÆ IN LINE OF SIGHT.

A very suggestive paper with title "On the Motions of the Planetary Nebulæ in the Line of Sight," has been published by James E. Keeler, of the Lick Observatory, in No. 11 of the Publications of the Astronomical Society of the Pacific. This paper contains a preliminary account of the researches in the spectra of the planetary nebulæ, and a statement of the results of measurements which show that some of the nebulæ which have hitherto been supposed to be at rest relatively to the solar system, have a considerable motion in the line of sight. The paper also gives a careful description of the different spectroscopes used and the objects observed. It is further stated "that in seeking to determine the motions of the nebulæ from these observations, a difficulty presented itself which does not occur in the observations of stars in line of sight. The origin of the brightest nebular line is unknown, and hence we have no terrestrial substance

with which to make a direct comparison. The position of that nebular line must therefore be determined in some other way. This was done by observations of nebulæ distributed with some degree of uniformity throughout the sky, assuming the mean position of the line as that due to a nebula without motion. The residuals obtained by comparing the individual results with this mean would represent the corresponding displacement of the line for each nebula. A table of the observations of a few nebulæ is made in this way as follows:

Motions of Planetary Nebulæ in the Line of Sight

(A positive sign signifies recession, a negative sign approach.)

Nebula	λ	Displacement	Motion per Second
	Tenth meters	Tenth meters	Miles
G. C. 4234 (Σ 5)	5005.38	− 0.30	− 11.2
G. C. 5841	5005.50	− 0.18	− 6.7
G. C. 4373	5005.85	− 0.83	− 31.0
G. C. 4390 (Σ 6)	5005.81	+ 0.13	+ 4.8
N. G. C. 6790	5006.71	+ 1.03	+ 38.4
G. C. 4510	5005.65	− 0.03	− 1.1
G. C. 4514	5005.87	+ 0.19	+ 7.1
G. C. 4628	5005.22	− 0.46	− 17.2
N. G. C. 7027	5006.13	+ 0.45	+ 16.8
G. C. 4964	5005.72	+ 0.04	+ 1.5
Mea	5005.68		

It is probable that a greater number of nebulæ would give a somewhat smaller mean wave-length for the position of the brightest line, and that therefore the motions of approach in the above table are too small. The single comparison of the third line in the spectrum of Σ 6 with the hydrogen line $H\beta$ also indicates a higher mean position of the nebular line, although the observation was subject to rather large accidental errors. The *difference* of motion of the nebulæ given in the table above I believe to have a considerable degree of accuracy,—*i. e.*, that the errors do not much exceed two or three English miles.

The spectra of the nuclei of planetary nebulæ have a remarkable resemblance to the spectra of the Wolf-Rayet and other bright-line stars, and intimate connection between these objects, if established by further observations, would

place the bright-line stars first in the order of development. The D_3 line appears in the central condensation of a number of bright nebulæ, and, with sufficient light, would probably be seen in many of them, and this line is also prominent in most of the bright-line stars. Other lines in the nebulæ and stars are probably of identical origin. At my request Mr. Burnham and Mr. Barnard examined the Wolf-Rayet stars in Cygnus for traces of surrounding nebulosity with only negative results."

At the close of this paper Mr. Keeler appends the following note:

"Since my paper was printed, I have seen No. 293 of the Proceedings of the Royal Society, in which Mr. Lockyer describes his recent observations, and arrives at conclusions which cannot be reconciled with my own. There is, however, nothing that I could wish to change in my paper, since it is simply a record of observed facts. In only one place (observations of Σ 6) have I referred the observed appearances to a cosmical theory, and the reader can easily supply any other explanation that is in accordance with the facts.

The errors which Mr. Lockyer mentions as liable to arise from imperfect adjustment of the collimator axis and from parallax, seem to me excessive, if the telescopes are good and the adjustments are carefully made, and if they existed they would make observations of motion in the line of sight impossible. Certainly no errors approaching them in magnitude are produced in my own apparatus, when, in testing for constant errors, the various adjustments were purposely disturbed by amounts greater than could occur in practice. Among the many experiments which were made was the one suggested by Mr. Lockyer—rotating the spectroscope 180° between measures, but no appreciable effect was produced upon the position of the nebular line.

As regards accuracy of positions, there is a great advantage in using a very high dispersion, such as was employed in these measures, since any angular displacement of the parts of the apparatus produces but a small error measured in wave-lengths. The measures are also *differential*, the reference line being in the same field and the telescope fixed in position. They are affected by any error in the assumed place of the reference line, but this is immaterial for the purposes of the investigation.

On referring to my measures, it will be seen that they apparently have a vastly higher degree of accuracy than that which Mr. Lockyer considers attainable. When it is remembered that these measures were made on different nights (the spectroscope usually having been dismounted in the interval), and frequently without any recollection of the results previously obtained, it appears in the highest degree improbable that the agreement of the different results for the same object should be the result of accident. In the observations of the motion of Venus in the line of sight the interval between the *D* lines appeared under an angle of 1° 17′, as viewed with the eye-piece, and any good observer, on noting the small displacement of the lines of the planet, would admit the possibility of measuring this displacement to within a tenth of its value. Hence the accuracy of the measures in this case cannot be regarded as accidental, and for the nebulæ, on which even a higher dispersion was employed, the probable error of a setting was not much greater.

In regard to the *character* of the chief nebular line I can only repeat that I see no tendency in it to assume the fluted appearance described by Mr. Lockyer either in the nebula of Orion or in the others I have observed, some of which are fainter, and some very much brighter. Near the nucleus of a nebula, if it has one, the lines are broader and hazy, but equally so on both sides, and, as nearly as their different degrees of brightness will allow one to judge, all the lines are affected alike.

For faint, extended nebulæ, the great focal length of the thirty-six inch equatorial is a positive disadvantage, and I do not attach much weight to the negative results obtained in the examination of some of these objects giving continuous spectra.

HOW TO MEASURE THE INVISIBLE.*

HENRY M. PARKHURST.

When Comte's Positive Philosophy was published, some forty years ago, Kirchhoff had not made the discovery which

* A lecture delivered before the astronomical department of the Brooklyn Institute, October 13, and illustrated with lantern views and diagrams. The remainder of the lecture will be given next month with the illustrations.

lies at the foundation of all spectroscopic analysis. It seemed then that there could be no question of the correctness of his assertion that the chemistry of the stars would be forever beyond the reach of human investigation. What could be more certainly impossible than that men of science, separated from the stars by millions of millions of miles of space, void with the exception of a possible ether, so etherial as not to perceptibly interfere with the motion of the rarest comets, could ascertain what substances exist, and their chemical nature, in those inconceivably distant orbs? His reasoning was good; but his argument contained a flaw in assuming as a self-evident fact that which was not a fact. The sense of sight alone can give us information with regard to the stars. No sound can cross the depths of space: still less can our other senses aid us; for they require close proximity if not actual contact as the basis of their indications. Comte argued that all that we could learn of the stars must be learned through the instrumentality of the sense of sight; and he assumed that it was absolutely impossible for us by the sense of sight to distinguish between the different chemical elements in the stars. Yet the discovery of the principle of the spectroscope has made this seeming impossibility possible. Comte's system of Positive Philosophy was founded upon the assumption that there were some things that men positively could not know; that it was useless to look for it or to hope for it; and this was one of them. Let me read to you his exact language:

"Of all objects, the planets are those which appear to us under the least varied aspect. We see how we may determine their forms, their distances, their bulk, and their motions, but we can never know anything of their chemical or mineralogical structure; and, much less, that of organized beings living on their surface."

Although the word "planets" is used in the translation of this sentence, it is of the stars that he is speaking, and the argument applies equally to the planets and the fixed stars. The fact that to-day, what he pronounced forever impossible, and there was no one to tell him nay, has already been attained, should be a lesson to us never to be positive of the impossibility of attaining any sort of knowledge. Whatever knowledge man has sufficient conception of to imagine

a theory with regard to, there is, so far as we know, a possibility of his reaching, in some way and at some time. As with regard to the mathematical computation that no steamship could ever cross the Atlantic, because the coal would not furnish sufficient power for its own transportation, it seems as if the very announcement of an impossibility, served but as a prelude to emphasize the marvellous achievement.

Before the invention of the telescope an object upon the moon's surface fifty miles in diameter could not be seen; and it seemed impossible that men should ever know anything about lesser objects. By the argument of Comte, man was forever debarred from knowing about such objects. Leaving out of view the possibility of optical magnification, the sense of sight having already reached the limit of its power, there was no basis left for further discoveries; and among absolute impossibilities, quality was no more to be rejected as unattainable than quantity. The invention of the telescope has introduced a new element before unthought of; and it has taught us the first mode of measuring the invisible; which is, first to make it visible, by magnifying it optically. The thousands of minute craters upon the moon's surface can now be measured; whereas before the invention of the telescope their existence could not be suspected. We have not yet learned what limitation attends this mode of magnification. Each new large telescope, making visible and measurable that which was before invisible, leads to the construction of another larger telescope; and the end is not yet. The great refractor of the National Observatory, when I was there, had an aperature of less than ten inches. Then came the Harvard refractor of fifteen inches. The Chicago telescope of eighteen inches suceeded. Others still larger followed, until the new refractor of twenty-six inches aperture replaced the old one at Washington. At last has come the Lick telescope of thirty-six inches, eclipsing all predecessors. And even now the Clarks are engaged in the construction of a still larger telescope, which is expected to excel even the Lick telescope.

Not only may we have larger telescopes, but new discoveries in the manufacture of the lenses may so improve their definition, by getting rid of the irrationality of the spectra,

as to still further increase their magnifying power. Such improvements cannot add much in the observation of excessively faint objects, but may add materially in observations where definition is required rather than light.

It will take many years to double the power of our largest telescopes, if it can ever be done; and it is natural to suppose that the power of measurement must await the improvement of the telescope. We may measure the invisible by first making it visible; but how can we measure it if we cannot make it visible? The sight is our only sense which reaches beyond our own little planet. If we cannot take cognizance of a distant object by our vision, how can we know that it exists?

One answer to this question it is not difficult to find. In an eclipse of the sun, we cannot see the moon; but we know that it exists from its intercepting the rays of the sun. Even if we never saw the moon at any other time, we should know in a solar eclipse that it existed. Or if that is considered too metaphysical, I will pass at once to another illustration.

The irregularities in the proper motion of Procyon have been found to indicate that it is accompanied by a body invisible to us, and yet of sufficient mass perceptibly to affect its motion. Procyon and this invisible body revolve around a common center of gravity. We know that this dark body exists, and we know approximately its direction from Procyon and the period of its revolution. But these facts do not give us any means of measurement. We cannot learn from these facts, so far as I can see, anything whatever with regard to the distance between the bodies, or their relative size, or absolute size, or anything which can properly be called a measurement. In like manner and still earlier, Sirius was found to have an irregular proper motion, inducing the belief that it was attended by an invisible companion. The subsequent discovery of the companion of Sirius, very faint but of considerable size, while it confirms the hypothesis of the cause of the irregularities in the motion of Procyon, makes it no longer possible to cite Sirius as an illustration of a bright star attended by a known invisible companion.

It has long been thought not improbable that the variable star, Algol, is accompanied by a dark body which at each

revolution, comes between us and the principal star, and cuts off a portion of its light, causing its brightness to fall from the second to the fourth magnitude. Here all that we see, and all that any telescope can show us, is the diminution of the light. If we knew that the dark body passed directly and centrally between us and the bright star, this would give us an approximation to the relative sizes of the two bodies; but even upon that hypothesis we could not know their actual size or distance. It is manifest that if the plane of the orbit should be, as it would be most likely to be, inclined to the line of sight (the line joining Algol and the earth), the dark body might not pass entirely across the disk of the other; so that it is impossible to say how much larger the dark body is, In the existing state of our knowledge it seems probable that the dark body is the smaller of the two. It is difficult to understand how one body can be glowing with heat, while another body of equal or larger size, under very similar conditions, is so cooled down as to cease to be luminous. To reduce this difficulty as much as possible, it is assumed that the dark body passes nearly centrally over the other at each revolution, and that its size is only enough to account for the amount of light obstructed. This does not remove the difficulty, but it reduces it. In any event there is so much hypothesis mixed with our known facts that our results cannot properly be called results of measurement, and such results are not measures of the invisible.

Yet we are not left to mere hypothesis in this case. The telescope enables us to measure the invisible by first making it visible; the spectroscope enables us to measure the invisible without making it visible; and this is the matter which I wish to-night specially to explain.

Let me first remark that the spectroscope not only upsets our preconceived notions of the possibilities of things, but reverses the order of its revelations. When an object is presented to our view, we first form some idea of its form, its distance and its size; and the investigation of its nature, and the nature of the substances of which it is composed, comes afterwards. But in these mysterious revelations of the spectroscope in the stellar universe, it first revealed to us the nature of the substances of which the stars were composed;

then whether gaseous or solid, whether of a high or low temperature; and its last achievement is the measurement of distances and of masses.

The principal star in the constellation Capricornus, is a double-star known before the invention of the telescope. The apparent distance of the two stars is about 6′. Soon after the application of the telescope to astronomical research it was found that there were much closer double-stars, so close as not to be distinguishable by the naked eye. Every advance in the improvement of the telescope has brought to our knowledge still closer double-stars, the distance between them being so magnified as to become visible and measurable. But the spectroscope has revealed to us a double-star so close that no telescope will show the distance between the two stars, although each one of the two stars is bright enough to be visible to the naked eye; and I shall endeavor to explain to you how it is capable theoretically of revealing to us the duplicity of stars so optically close that no possible telescope of the future could ever separate them.

In order to make this intelligible, it will be necessary for me to explain what the spectroscope is, and how it gives us information. As preliminary to that, and to make its indications certain, on their face, I must speak of the nature of light, and especially of color. I shall speak of these points with sole reference to explaining and demonstrating this latest achievement of the spectroscope.

I will not go back in the history of the spectroscope to the time of the flood, when the colors of the rainbow first attracted attention; but will begin with the time of Newton, who in 1664 studied those same colors produced by refracting the sun's rays through a glass prism. He found the solar rays to consist of rays of different degrees of refrangibility. When the aperture through which the sunlight was received upon the prism was a circular hole in the shutter, each kind of light formed a circle in a different place, according to its refrangibility, the different circles lapping over each other and mingling their colors. By changing the form of the aperture to a slit, he found that the colors became much more pure. Carrying out the same plan to greater perfection Wollaston observed in 1802 some of the principal dark lines in the spectrum, which he considered as the boundary lines

between the different pure colors. These lines were carefully observed and mapped by Fraunhofer in 1814. Were the rays of light of all degrees of refrangibility between certain limits, there would be no dark lines. In the continuous spectrum of an incandescent non volatile substance, such as carbon under ordinary conditions there are no dark lines. The existence of these dark lines in the sunlight shows that there are certain degrees of refrangibility which do not exist in the sunlight as it comes to us. It was the discovery by Kirchhoff in 1859 of the cause of this, of the way in which these kinds of rays in the original light from the incandescent body of the sun are weeded out of the continuous spectrum by glowing gases in the sun's atmosphere, which was the first step in the science of spectroscopy.

When common salt is put into the flame of a Bunsen burner, instead of its light becoming diffused in a continuous spectrum, it is wholly confined to two narrow lines, close together. Upon comparing the position of these two lines with the lines of the solar spectrum, it had been found that they exactly, or at least very nearly, corresponded with Fraunhofer's two D lines. Kirchhoff traced the identity of the lines, and showed it demonstrated the existence of the vapor of sodium in the sun's atmosphere. It is remarkable how nearly the discovery had been made many years before. Even before the discovery of the lines in the solar spectrum, Euler, reasoning from the nature of wave motion, had enunciated the principle that "Every substance absorbs light of such a wave length as coincides with the vibrations of its smallest particles."

Again, in 1853, Angstrom enunciated the principle that "A luminous gas absorbs rays of the same refrangibility as those which it emits." But although these principles were enunciated, there does not appear to have been any attempt to verify them by experiment, or any clear conception of the resulting consequences, until the observations of Kirchhoff in 1859. From direct comparison of the two bright sodium lines with the two dark D lines of the solar spectrum, and from observation of the effect of a sodium flame to produce the same two dark lines when a bright light shone through it, Kirchhoff was convinced of the existence of the vapor of sodium in the sun's atmospher, and at once

proceeded to investigate what other chemical elements could be found to exist in the sun's atmosphere by the appearance of their lines in the solar spectrum. His most remarkable result was the discovery that more than sixty dark lines in the solar spectrum exactly coincide with as many of the bright lines produced by the vapor of iron; demonstrating the existence of iron in the form of vapor in the sun's atmosphere. And later there have been found to be no less than 460 iron lines in the solar spectrum. Various other chemical elements are also identified. But for my present purpose it is enough to have made it apparent that the cause of the dark lines in the spectrum of the sun and of the stars is known, and that we can safely rely upon the conclusions which follow from the phenomena which we observe in relation to them.

(TO BE CONTINUED.)

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at superior conjunction with the sun on Nov. 16, so that he will not be in good position for observation during November.

Venus is approaching inferior conjunction, and although very brilliant cannot be well observed after sunset. The best views are obtained from one to two hours before sunset. The diameter of Venus' disk increases from 44.4″, Nov. 2, to 64.6″, Dec. 3, when the planet, at 10^h P. M., will be in conjunction with the sun, at a distance of only 15′ from the sun's southern limb. The phase of the planet decreases in the same time from 0.224 to 0.000. On Nov. 29, at 1:30 P. M., Mercury and Venus will be in conjunction, Mercury being only 10′ north of Venus. This conjunction will, however, occur so close to the sun that it will probably be impossible to see either of the planets.

Mars continues to set at about the same time each evening, in the southwest. His progress eastward among the stars is very noticeable. He will pass by Jupiter on Nov. 13 at 5 P. M., passing 59′ south of the latter. The diameter of Mars' disk is now so small and his altitude so low in the evening that no satisfactory views of his surface can be obtained.

A friend sends us a clipping from the Washington *Evening Star*, Oct. 11, 1890, giving an interesting note, in which Professor W. H. Pickering is represented as thinking that the planet Mars is dying. He, however, says "It is all a hypothesis after all. There is no definite proof. We know that there are great patches of white in the polar regions of the planet and that they increase in winter and diminish in summer. This fact is abundantly

confirmed by the photographs taken by the Harvard College astronomers at our station on Mount Wilson in Southern California. On the night of the 10th of April we took an observation and on the succeeding night another one. On the second occasion we found that the white space in the southern hemisphere had increased twenty during the four hours by an area nearly as large as the United States. So you see if this white appearance is due to snow there must have been a tremendous snow-storm in Southern Mars on the 10th of April."

In this connection a note from a recent letter from Mr. Charles Burckhalter, of Chabot Observatory, will be interesting. He gives the following transcript from his note book: "June 9th observed Mars, and, as usual the northern snow cap appeared the larger, but on the 10th, I saw at a glance that the southern cap was twice as large as the northern." He then put down more for amusement than anything else this query: "Was there a great snowstorm at the south pole of Mars between June 9 and 10, 1890."

Whether we may interpret the white appearance of the poles of Mars as due to the presence of snow or of clouds, we have abundant evidence of great and sudden changes in them. The fact that two astronomers widely separated, interpret similar phenomena in the same way shows at least that their interpretation is a natural one.

Jupiter is moving forward again through the constellation Capricorn. The procession of the three bright planets descending toward the southwest horizon in the early evening, has been a noticeable one during the past month, Venus leading, Mars following and Jupiter bringing up the rear in their diurnal motion. Jupiter will catch up with Mars, or rather Mars will catch up with Jupiter in his eastward motion on Nov. 13. It will help our understanding of the different distances of celestial bodies apparently close together, to know that the distance of Mars on Nov. 13 will be about 119,000,000 miles, while that of Jupiter, in almost the same direction, will be 486,000,000 miles.

On the night of Sept. 8, while Mr. Barnard was observing Jupiter with the 12-inch equatorial of the Lick Observatory, he noticed that Satellite I, in transit across the disc of the planet, appeared to be double. "Upon applying high powers (500 and 700 diameters), and with as perfect seeing as we have ever had on the mountain, the satellite distinctly appeared double, the apparent components being in a line nearly vertical to the belts of Jupiter. A line of light was occasionally seen separating the satellite into two nearly equal parts." Mr. Burnham also distinctly saw the phenomenon of duplicity. Mr. Barnard says: "There are only two explanations of what we saw. A white belt on the satellite parallel to the belts of Jupiter, would, perhaps, satisfactorily explain the phenomenon. If this is not the explanation, there is no other alternative but to consider the satellite actually double. Its shadow was apparently round. The satellite was examined when off the planet later, but the images were too indifferent to decide upon anything."

Saturn may be observed in the morning. He is in the eastern part of the constellation of Leo, seen toward the east after 2 A. M. The angle of the earth from the plane of the rings is now only 3° and decreasing, so that

the rings are seen almost edgewise, and therefore indistinct. We give this month the times of elongation of the five brighter satellites of Saturn, which can be seen with telescopes of moderate power.

Uranus is too nearly in line with the sun to be seen during this month.

Neptune will be at opposition Nov. 27, and is therefore in excellent position for observation. He is at nearly 20° north declination, so that in our latitude he reaches a very high meridian altitude. He may be found in Taurus almost on a line from Aldebaran to the Pleiades, 1° west and 45′ north of the fourth magnitude star ϵ Tauri, almost exactly north of the sixth magnitude star which follows ϵ Tauri.

Date. 1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
			MERCURY.		
Nov. 25	16 25.4	− 22 53	7 40 A. M.	12 06.9 P. M.	4 33 P. M.
Dec. 5	17 32.9	− 25 17	8 21 "	12 35.0 "	4 49 "
15	18 42.1	− 25 23	8 52 "	1 03.5 "	5 15 "
			VENUS.		
Nov. 25	17 01.2	− 25 24	8 30 A. M.	12 42.7 P. M.	4 56 P. M.
Dec. 5	16 38.0	− 22 18	7 11 "	11 40.2 "	4 09 "
15	16 18.2	− 19 08	5 57 "	10 41.1 "	3 25 "
			MARS.		
Nov. 25	21 08.8	− 18 00	12 00 M.	4 49.4 P. M.	9 39 P. M.
Dec. 5	21 38.1	− 15 31	11 39 A. M.	4 39.1 "	9 39 "
15	22 06.8	− 12 49	11 16 "	4 28.5 "	9 40 "
			JUPITER.		
Nov. 25	20 40.4	− 19 08	11 37 A. M.	4 20.7 P. M.	9 05 P. M.
Dec. 5	20 47.4	− 18 41	11 02 "	3 48.4 "	8 35 "
15	20 55.2	− 18 10	10 28 "	3 16.7 "	8 05 "
			SATURN.		
Nov. 25	11 12.2	+ 7 05	12 21 A. M.	6 54.5 A. M.	1 28 P. M.
Dec. 5	11 14.2	+ 6 56	11 43 P. M.	6 13.3 "	12 44 "
15	11 15.4	+ 6 51	11 05 "	5 35.1 "	12 06 "
			URANUS.		
Nov. 25	13 49.6	− 10 43	4 11 A. M.	9 31.6 A. M.	2 52 P. M.
Dec. 5	13 51.3	− 10 53	3 34 "	8 54.1 "	2 14 "
15	13 53.4	− 11 04	2 58 "	8 16.7 "	1 36 "
			NEPTUNE.		
Nov. 25	4 15.3	+ 19 35	4 35 P. M.	11 54.8 P. M.	7 15 A. M.
Dec. 5	4 14.2	+ 19 32	3 54 "	11 14.3 "	6 35 "
15	4 13.0	+ 19 29	3 13 "	10 33.9 "	5 54 "
			THE SUN.		
Nov. 20	15 44.5	− 19 49	7 05 A. M.	11 45.9 A. M.	4 27 A. M.
25	16 05.8	− 20 52	7 11 "	11 47.3 "	4 23 "
30	16 27.2	− 21 44	7 16 "	11 48.0 "	4 20 "
Dec. 5	16 48.9	− 22 27	7 23 "	11 50.9 "	4 19 "
10	17 10.8	− 22 58	7 28 "	11 53.1 "	4 19 "
15	17 32.9	− 23 18	7 32 "	11 55.5 "	4 19 "
			THE MOON.		
Nov. 20	23 27.8	− 9 11	1 58 P. M.	7 28.2 P. M.	1 10 A. M.
25	3 52.9	+ 18 53	4 04 "	11 32.8 "	7 13 "
30	8 33.9	+ 22 57	7 55 "	3 53.5 A. M.	11 44 "
Dec. 6	12 32.4	+ 1 50	1 08 A. M.	7 31.5 "	1 45 P. M.
11	16 53.0	− 22 32	6 53 "	11 31.7 "	4 01 "
15	21 14.5	− 20 48	10 55 "	3 37.0 P. M.	8 26 "

Phases and Aspects of the Moon.

			Central Time. d	h	m	
First Quarter	1890	Nov.	19	6	45	A. M.
Full Moon	"	"	26	7	23	"
Last Quarter	"	Dec.	4	7	27	A. M.
New Moon	"	"	11	9	11	P. M.
Perigee	"	Nov.	18	12	00	M.
Apogee	"	Dec.	3	12	24	A. M.
Perigee	"	"	14	6	36	P. M.

Occultations Visible at Washington.

			IMMERSION.		EMERSION.		
Date.	Star's Name.	Magnitude.	Wash. Mean T. h m	Angle f'm N. P't. °	Wash. Mean T. h m	Angle f'm N. P't. °	Duration. h m
Nov. 18	B.A.C. 7550	6½	8 32	143	8 58	185	0 26
28	ε Geminorum	3½	11 19	24	12 04	317	0 45
29	κ Geminorum	3½	14 35	82	16 02	297	1 28
Dec. 1	B.A.C. 3206	6½	12 40	116	14 00	272	1 20
2	η Leonis	3½	9 58	53	10 36	329	0 38

Saturn's Satellites.

[Central Time; E = eastern elongation; I = inferior conjunction; W = western elongation ; S = superior conjunction.]

JAPETUS.

Nov. 18	W.	Dec. 8	S.	Dec. 28	E.

TITAN.

Nov. 15	6.2 A. M.	E.	Nov. 27	6.1 A. M.	S.	Dec. 9	5.7 A. M.	W.
19	6.2 "	I.	Dec. 1	6.1 "	E.	13	5.5 "	S.
23	6.2 "	W.	5	5.9 "	I.			

RHEA.

Nov. 16	8.3 A. M.	E.	Nov. 29	9.8 P. M.	E.	Dec. 13	11.1 A. M.	E.
20	8.8 P. M.	E.	Dec. 4	10.3 A. M.	E.			
25	9.3 A. M.	E.	8	10.7 P. M.	E.			

DIONE.

Nov. 16	5.6 A. M.	E.	Nov. 26	4.3 A. M.	E.	Dec. 7	3.2 A. M.	E.
17	11.2 P. M.	E.	28	10.1 P. M.	E.	9	8.9 P. M.	E.
20	4.9 P. M.	E.	Dec. 1	3.8 P. M.	E.	12	2.6 P. M.	E.
23	10.6 A. M.	E.	4	9.5 A. M.	E.	15	8.3 A. M.	E.

TETHYS.

Nov. 15	7.2 P. M.	E.	Nov. 25	5.9 A. M.	E.	Dec. 4	4.4 P. M.	E.
17	4.6 P. M.	E.	27	3.2 A. M.	E.	6	1.7 P. M.	E.
19	1.9 P. M.	E.	29	12.5 A. M.	E.	8	11.0 A. M.	E.
21	11.2 A. M.	E.	30	9.8 P. M.	E.	10	8.4 A. M.	E.
23	8.5 A. M.	E.	Dec. 2	7.1 P. M.	E.	12	5.7 A. M.	E.
						14	3.0 A. M.	E.

Phenomena of Jupiter's Satellites.

	Central Time. h. m.				Central Time. h. m.		
Nov. 17	5 03	P. M.	II. Sh. Eg.	Dec. 1	5 00	P. M.	II. Tr. In.
17	6 02	"	I. Oc. Dis.	3	4 30	"	I. Oc. Dis.
18	5 33	"	I. Tr. Eg.	3	4 37	"	II. Ec. Re.
20	5 23	"	III. Sh. In.	4	5 08	"	I. Sh. Eg.
24	5 12	"	II. Tr. Eg.	11	4 45	"	I. Sh. In.
25	5 12	"	I. Tr. In.	12	4 18	"	I. Ec. Re.
25	6 23	"	I. Sh. In.				
26	5 59	"	I. Ec. Re.				

Minima of Variable Stars of the Algol Type.

	R.A. h m s	Decl. ° ′	Central Times of Minima.
U Cephei	0 52 32	+ 81 17	Nov. 17, 6 P.M.; 22, 6 P.M.; 27, 5 P.M. Dec. 2, 5 P.M.; 7, 4 P.M.; 12, 4 P.M.
Algol	3 01 01	+ 40 32	Nov. 17, 10 P.M.; 20, 7 P.M.; Dec. 7, midn Dec. 10, 9 P.M.; 13, 5 P.M.
λ Tauri	3 54 35	+ 12 11	Nov. 15, 11 P.M.; 19, 9 P.M.; 23, 8 P.M. Nov. 57, 7 P.M.; Dec. 7, 6 P.M.; 5, 5 P.M.
R Canis Maj.	7 14 30	− 16 11	Nov. 23, 3 A.M.; 24, 6 A.M.; Dec. 1, 2 A.M. Dec. 2, 5 A.M.; 10, 4 A.M.
S Cancri	8 37 39	+ 19 26	Nov. 18, 1 A.M.; Dec. 6, midn.

Solar prominences for September 1890. Number of observations, 10; number of prominences, 36; mean number of prominences, 3.6; highest prominence, 96″ (on the 29th).

DISTRIBUTION OF PROMINENCES IN LATITUDE.

Between	E. Limb.	W. Limb.	Between	E. Limb.	W. Limb
0 and + 10°	0	3	0 and − 10°	5	2
+ 10 and + 20	0	2	− 10 and − 20	1	0
+ 20 and + 30	0	2	− 20 and − 30	2	0
+ 30 and + 40	0	3	− 30 and − 40	1	1
+ 40 and + 50	0	0	− 40 and − 50	0	0
+ 50 and + 60	0	1	− 50 and − 60	0	0
+ 60 and + 70	0	0	− 60 and − 70	0	0
+ 70 and + 80	0	0	− 70 and − 80	2	0
+ 80 and + 90	3	3	− 80 and − 90	0	5
				14	22

Camden Observatory, Oct. 1, 1890.

Smith Observatory Observations: The following solar observations were made with telescopes unless otherwise stated. They were taken by Charles E. Peet:

1890.	90° Mer. M. T.	Groups.	Spots.	Faculæ.	Seeing.	Remarks.
Sept. 16	5:45 p m	2	6	1	Bad.	
17	2:05 p m	2	12	0	Fair.	Gran. good.
18	5:20 p m	2	10	0	Fair.*	
20	8:05 a m	1	8	0	Good.	Gran. good.
21	5:15 p m	0	0	1	Fair.	Fac. mottlings on NE limbs.
22	5:30 p m	0	0	1	Poor.*	
23	1:25 p m	0	0	2	Good.*	
24	3 p m	0	0	0	Bad	Seeing too poor to distinguish.
26	2:35 p m	1	22	0	Good.	Veil about 3 of the spots.
27	2:25 p m	1	10	0	Bad.	
28	12:50 p m	1	9	0	Fair.	Gran. good.
30	2:50 p m	1	3	0	Bad.	Seeing too poor to distinguish much.
Oct. 2	2:35 p m	1	2	1	Poor.*	Large faculous regions about spots.
3	1:25 p m	0	0	1	Fair.*	Gran. large.
5	3 p m	1	2	0	Bad.*	Glimpsed thro' clouds for one moment.
6	2:15 p m	1	2	0	Bad.*	Glimpsed through clouds.
7	2:30 p m	1	3	1	Good.*	Gran. good.
10	3:45 p m	0	0	0	Bad.*	Haze thick.
12	3:00 p m	0	0	0	Fair.	
14	1:20 p m	1	2	0	Bad	CHAS. A. BACON.

* Projection on 20 cm. circle.

Carleton College Sunspot Observations. Continued form page 325.)

1890.	Central Time.	Groups.	Spots.	Faculæ.	Observers.	Remarks.
July 15	9:16	0	0	2 gr.	C. R. W.	2 large gr. of fac. 1 E. and 1 W.
16	2:00	0	0	1 "	"	Fac. W.
17		0	0	0 "	"	
23	10:00	2	6	3 "	H. C. W.	Small spot with large gr of fac S. of centre. Large spot with a few smaller ones and many fac near SE limb.
26	12:30	1	10	0 "	"	Large spot followed by smaller ones.
28	10:00	2	6	1 "	"	New large spot near E. limb
29	12:30	3	9	3 "	"	New small spot in SE quadrant Large spot near E. limb followed by large gr of fac
31	12:30	2	3	3 "	"	New gr of July 29 has disappeared. Large spot of July 23 diminished to two very small spots
Aug 1	12:40	3	9	2 "	"	New gr of spots SE of center, probably a revival of gr of July 29. New gr fac at SE limb
4	12:35	1	4	2 "	"	The large spot of July 28 is breaking up.
5	12:50	2	12	2 "	"	New gr of 8 small spots SE of center
6	5:05	2	8	2 "	"	
8	12:05	0	0	1 "	"	Large gr of fac near NW limb
9	12:35	0	0	2 "	"	Fac NW and W
11	12:45	1	2	1 "	"	2 new small spots NW of center Fac W
13	12:20	0	0	5 "	"	5 single fac near different points of limb.
14	4:40	1	2	0 "	"	2 small spots near E limb
15	12:10	0	0	0 "	"	
19	12:15	0	0	1 "	"	Fac SE
21	4:50	0	0	0 "	"	
22	11:50	1	1	0 "	"	One small spot about ¼ way from center to S point of limb
25	12:30	1	0	1 "	"	Large gr of fac with a few spots at E limb
26	12:40	2	27	3 "	"	Gr near E limb has broken up into many small spots New gr near W limb
27	9:45	2	33	2 "	"	
28	12:15	1	30	1 "		
29	10:50	1	25	0 "	"	
30	12:20	1	30	0 "	"	2 fine large spots.
Sept. 1	12:30	2	35	0 "	"	New gr. on S. hemisphere.
5	10:30	2	12	0 "	"	
9	1:35	1	7	0 "	"	
13	12:30	0	0	0 "	"	
16	12:30	2	4	1 "	"	One large spot SE. Gr. of 3 smaller spots further W. Fac. NW.
19		3			H C W.	
22	10:30	0	0	2 "	C. R. W.	Two large gr. of fac., 1 SE., 1 W.
23	12:45	0	0	2 "	"	Gr of fac on the E larger and less brilliant than on 22d.
24	2:00	1	8	2 "	H. C. W	
27	12:40	1	10	1 "	C. R. W.	Faculæ SW.
29	9:25	1	11	1 "	"	Faculæ SW
30	2:10	1			"	
Oct. 1	3.40	1	4	1 "	"	
4	12:35	1	2	4 "	"	
14	2:30	1	2	2 "	"	Spots small. One gr. fac. E., other W.
15	12:30	0	0	2 "	"	One gr. fac. E., other W.
16	10:20	0	0	0 "	H. C. W.	
17		0	0	0 "	W W P.	
20	9:25	2	11	2 "	C. R. W.	2 gr. of spots near E. limb. One gr. very small and surrounded by fac.
21	12:30	2	17	1 "	"	One gr finely developed containing 15 spots.
22	12:30	2	17	1 "	"	One gr.

Koreshan Astronomy. Under this title in the September *Budget* (California) will be found one of the most remarkable articles of the present decade. If the writer has survived that effort he surely will never fossilize in this geological stratum of human knowledge. He is embryonic of something to come, nobody can imagine what.

COMET NOTES.

Ephemeris of Comet c 1890 (Denning July 23). From Dr. Krueger's elements as given in *A. N.* Vol. 125, p. 219, I have computed the following ephemeris.

Although this comet will be so low and faint by Nov. 1, that it probably will be practically out of reach of northern observatories, yet, as it is possible that it may be seen in the southern hemisphere, I subjoin the following ephemeris.

If we assume its light on Oct. 1 as unity, its light on Nov. 1 will be 0.50 and on Nov. 30, 0.28.

Ephemeris of Comet c, 1890 (Denning July 23.)

Gr. M. T.	App. R. A. h m s	App. Dec. ° ′	Log. *r*.	Log. Δ.
Nov. 1.5	16 38 22	− 34 11	0.1414	0.3165
2.5	39 34	34 43		
3.5	40 47	35 14		
4.5	42 1	35 46		
5.5	43 16	36 16	0.1494	0.3282
6.5	44 32	36 46		
7.5	45 48	37 16		
8.5	47 5	37 46		
9.5	48 24	38 15	0.1579	0.3391
10.5	49 42	38 44		
11.5	51 2	39 12		
12.5	52 24	39 41		
13.5	53 44	40 9	0.1667	0.3491
14.5	55 7	40 37		
15.5	56 30	41 4		
16.5	57 54	41 32		
17.5	16 59 18	41 59	0.1758	0 3583
18.5	17 0 45	42 26		
19.5	2 12	42 52		
20.5	3 39	43 19		
21.5	5 8	43 45	0.1851	0.3667
22.5	6 38	44 11		
23.5	8 10	44 37		
24.5	9 41	45 2		
25.5	11 14	45 28	0.1946	0.3743
26.5	12 49	45 53		
27.5	14 25	46 18		
28.5	16 1	46 44		
29.5	17 38	47 8	0.2042	0.3813
30.5	17 19 16	− 47 33		

O. C. WENDELL.

Harvard College Observatory, Oct. 11, 1890.

Comet of Barnard (October 6.) The faint comet discovered by Barnard on October 6, is undoubtedly that of D'Arrest. A hasty comparison of his position with that of an ephemeris, published by Leveau in *Comptes Rendus*, Tome CX, No. 3. page 121, gives for a correction to the computed place $\Delta\alpha = -6^m.6$; $\Delta\delta = -1'$. Cloudy and rainy weather has prevented us from getting any observations at the Naval Observatory.

E. FRISBY.

The Re-discovery of D'Arrest's Comet. On Oct. 6, I discovered a large faint comet in Sagittarius with the 12-inch equatorial. From the first three observations Mr. Schaeberle computed a preliminary orbit. Upon comparing this orbit with those of the catalogues it was at once seen that the object was the long searched for D'Arrest's comet which had been given up as lost, so far at least, as this return was concerned. The re-discovery of this comet was purely in the line of original search, as the search for D'Arrest's had been given up as hopeless, like that of Brorsen's. The identity with D'Arrest's comet was not even suspected until its orbit was computed. The accidental discovery of this comet after such a thorough and exhaustive search for it, and long after it had passed its most favorable position, brings up an important question as to the condition of its light for the past six months. It has become very much brighter since my first observation on Oct. 6, and an object one-tenth as bright could be easily observed. The position of the comet was on Oct. 15, $7^h\ 7^m\ 15^s$ Mt. Hamilton M. T.

α app. $19^h\ 49^m\ 52^s.9$ δ app. $27°\ 33'\ 19''$

which gives the correction $-0^m.5 - 3'$ to M. Leveau's ephemeris in *A. N.* 2959. E. E. BARNARD, Mt. Hamilton, Oct. 16, 1890.

Comet 1890 II (Brooks, March 16). This comet may be seen in the morning about two hours before sunrise. The following ephemeris is taken from *Astr. Nach.* No. 2995.

1890		α app.	δ app.	log r	log Δ	H
Nov.	5	$13^h\ 11^m\ 0^s$	$+26°\ 3'.0$	0.4288	0.5118	0.42
	7	11 12	25 58.9			
	9	11 21	25 55.5	0.4340	0.5100	0.42
	11	11 28	25 52.9			
	13	11 33	25 51.1	0.4391	0.5078	0.41
	15	11 35	25 50.1			
	17	11 34	25 49.8	0.4442	0.5051	0.41
	19	11 30	25 50.3			
	21	11 22	25 51.6	0.4493	0.5019	0.40
	23	11 11	25 53.7			
	25	10 56	25 56.6	0.4544	0.4983	0.40
	27	10 38	26 0.3			
	29	10 16	26 4.8	0.4594	0.4943	0.40
Dec.	1	9 50	26 10.1			
	3	9 19	26 16.2	0.4644	0.4899	0.40
	5	8 43	26 23.1			
	7	8 2	26 30.8	0.4694	0.4825	0.40
	9	7 16	26 39.3			
	11	6 25	26 48.6	0.4744	0.4803	0.40
	13	5 29	26 58.7			
	15	13 4 27	+27 9.7	0.4793	0.4751	0.40

Sternwarte Wien-Währing 1890 Sept. 22. *Friedrich Bidschof.*

Comet 1889 II (Barnard). Professor E. Millosevich, at the Observatory at Rome, has computed the elements of the orbit of this comet, using all the published observations from March 31 to Nov. 21, 1889, and finds the eccentricity to be very nearly unity. He finds that these elements satisfy very closely the observation by Mr. Barnard August 23, 1890, when the comet had reached a distance of 5.054 times the earth's distance

from the sun and 4.063 from the earth. The elements referred to the plane of the equator are.

$$\left.\begin{array}{rl} T & = 1889 \text{ June } 10.8098285 \text{ Berlin M. T.} \\ \pi' & = 11^\circ\ 34'\ 04.42'' \\ \Omega' & = 224\ \ 21\ \ 06.95 \\ i' & = 162\ \ 26\ \ 12.74 \\ \log q & = 0.3532083 \qquad q = 2.25532 \\ e & = 0.9995208 \end{array}\right.$$

(Equator 1889.0 — for π', Ω', i')

NOTES AND NEWS.

One of the rough discs from Jena for the new 16-inch telescope for Carleton College Observatory has been received by Mr. Brashear, of Allegheny. It is now being tested by himself and Dr. Hastings of Yale University.

From a recent private letter we learn that Professor C. A. Young, of Princeton is to have a new powerful spectroscope, and Mr. Brashear of Allegheny is given the contract for its construction.

Lawrence University Observatory. We are pleased to know that Lawrence University, Appleton, Wisconsin, is to have a new Astronomical Observatory. In November, 1889, Professor Underwood of that institution undertook the work of securing such an equipment, consisting of the following instruments: A 10-inch Clark equatorial, 4-inch transit circle, sidereal clock, a mean time clock, chronograph and spectroscope. The business men of Appleton have given the building, and the Methodist people of the state are putting in the instruments. The Observatory will be ready for use, as now planned, in September, 1891. Professor Underwood is to be congratulated.

Memoirs of the Royal Astronomical Society. Part II, Vol. 49 (1887–89) of the Memoirs of the Royal Astronomical Society is received. This part contains four papers: 1. A discussion of Greenwich observations of north polar distance with reference to the position of the Ecliptic and an annual variation of the value of co-latitude, by W. G. Thackery. 2. On the belts and markings of Jupiter, by N. E. Green, with four full page plates in color. 3. The total eclipse of the sun, 1887, Aug. 19, by Professor J. Arai, Director of the Tokio Observatory, Japan, with one plate, and four Photographs and drawings of the sun by Rev. S. J. Perry, D. Sc., F. R. S., with three full page plates.

We have from time to time made full reference to most of these important papers while presenting the subjects to which they refer in recent numbers of the MESSENGER, the last two especially. The plates are beautifully executed, and contain an amount of detail shown only in the best work of the kind. At the close of this part is found a complete list of persons to whom the medals or testmonials of the society have been adjudged. The list contains the names of 78 persons, the first award of the gold medal being made June 13, 1823, to Charles Babbage, Esq., for his invention of

an engine for computing and printing mathematical tables, and the last was adjudged to M. Maurice Lœwy, for his equatorial Coudé, his method of determining the constant of aberration and his other astronomical researches.

Variation of Latitude. It seems to be well settled (see *A. N.* No. 2993) that the latitude of places varies from time to time, by small amounts, perhaps not exceeding half a second. While the great argument for such changes, the supposed diminution of the latitude of Greenwich by a whole second or more since 1750, has been entirely confuted by Auwers' new reduction of Bradley, it is now known that the latitude of four or five stations in Germany has varied somewhat irregularly, as it seems, from season to season, of the same year, 1889. The investigation was begun on the testimony of Küstner's observation of 1884-5.

The article just quoted confirms the original observations by Pulcova determinations of the same year. The Pulcova series was made with the great vertical circle of Ertel, which has been re-divided by the Repsolds; and the probable error of one observation of the Polar star (really, I believe, four complete observations are made every time) is $\pm$ 0″.136; so that it has been quite possible, by a comparison of ten such "observations" in the fall of 1884, with 34½ smaller ones in the spring of 1885, to deduce a diminution of latitude equal to $-$ 0″.33 $\pm$ 0″.05. Dr. Küstner himself had determined at Berlin a similar diminution equal to $-$ 0″.49 $\pm$ 0.03, but with an additional probable error of nearly 0″.1 owing to doubts concerning the constancy of observations; as he employed a great "universal transit" used as a zenith telescope.

Certain practical considerations may be added. The Pulcova vertical circle is an instrument (like a great theodolite or alt-azimuth) in which the zero-points are determined by level-readings; and the "universal transit," with an aperture of 4.6 English inches has a prism in the cube, and the eye-piece in the axis. So that the prejudices which some American observers cherish against the level and the "broken telescope," as means of the most exact observation are quite groundless, and disappear entirely when the instruments in question are rightly made and properly handled.

But the time is quite gone by when rough instrument making can be tolerated. T. H. S.

The Great Forty-Inch Lens. In a recent number of the Boston *Herald*, is found an interesting account of an exhibit of the great forty-inch lens, by the Clarkes, of Cambridgeport, Mass. This is one of a pair of lenses intended for the great telescope to be placed on Wilson's Peak of the Sierra Madre range of mountains, distant from Los Angeles about twelve or fifteen miles, and which will form the objective of the new equatorial that will be the principal instrument of a new Observatory for the University of Southern California. This large lens was exhibited to a party of friends a few weeks ago, an account of which has already appeared in several eastern papers, and hence, only a few facts about the lens will be given at this time.

The diameter of the glass is said to be forty inches, two and one-half

inches thick at the center and one and one-half inches at the edge. Its value as a rough disc is not given. It is said to be insured for large sums of money in two of the leading companies of Boston. When both lenses of the objective are completed and in the cell, this part of the great telescope will probably cost about $65,000. In the article above referred to, it is said that the Clarkes are uncertain yet whether they will grind the discs at their shop in Cambridgeport, Mass., or build new shops near Mount Wilson and do this part of the work there. It is mentioned that the transportation alone of the Lick object glass cost $3,000. This course may be pursued to avoid expense and additional risk in transportation. This new telescope is to have a photographic lens, in all probability, though that point, as far as we know, is not yet part of the contract. If this telescope shall be completed, as indicated in this report and others previously made, the diameter of its object-glass will be four inches greater than that of the Lick telescope, and it will have a focal length somewhere between 56 and 60 feet, exactly how long, the Clarkes will not know till the lenses are finished. The focal length of the Lick telescope is 57 feet. The observatory floor of the Lick is 4,209 feet above sea level. The height of Wilson's peak is said to be 6,000 feet above sea level. It is also claimed by the friends of the new Observatory, that its site offers superior advantages to those of Mount Hamilton on account of frequent fogs that roll in from the Golden Gate. How this is we do not know, but it would seem, from a casual view of the shape of Wilson's Peak, that much and great unsteadiness of air might be expected at either day or night. We sincerely hope that we are wrong in this anticipation, for if true, it would prove a terrible drawback to continuous work, or excellent work even of discontinuous kind.

Publications of the Leander McCormick Observatory. Volume I part 4 of the Publications of the Leander McCormick Observatory, University of Virginia, is devoted to double-stars. The working list of stars included all known pairs between 30° and 0° of declination which were less than 4″ of distance apart, and several very close and difficult pairs north of the equator which for special reasons needed observation. The observers were F. P. Leavenworth and Frank Muller. The 26-inch equatorial was used with eye-pieces ranging from 200 to 2,000. It is noticed that in nearly all the observations, a right-angled prism was placed before the eye-piece by revolving which the double-stars could be made to assume any apparent position-angle desired. In getting position-angles the stars were made to bisect the space between two close wires, first with a forward and then with a backward rotation of the micrometer-box, the observer being careful that the apparent position-angle was zero at the moment of observation. For distance between components the usual method of measure was employed.

The observer in double-star work will find this catalogue a useful one both in regard to matter and method.

On the Law of Attraction of the Stellar Systems is the title of a paper by T. J. J. See, a student in astronomy at the Royal Frederick William University of Berlin, Germany. This paper proposes a method by which the

spectroscope may be applied rigorously to test the universality of the law of Newton. We have not the space to present the steps of the argument of this interesting paper, we can only give the results in brief, as derived by the author, an American student of prominence in higher mathematical researches.

The conclusion from an astronomical point of view, is, that it is impossible to conclude, from a rigorous example, that the law of Newton presides over the movements of the double-stars, although this is very probable. Professor Hall's view on this point is quoted in the following words: "Since we can only observe the following orbits (double-stars) and the fact that they describe equal areas in equal times, we may conclude that the force is central, but we cannot determine the law of this force as in the case of planetary motions. The difficulty arises from the fact that the focus of the real orbit is not generally projected upon the focus of the apparent orbit in which we observe the equal description of areas. Our inference of Newton's law must be from analogy." Professor Hall further says: "The theoretical difficulty in proving the law of Newton for the double-stars can not be overcome. But we may increase the probability of the existence of this law, by determining more orbits and those differently situated. If the law proves satisfactory in all cases, we shall have a probability of its universality increasing with the progress of astronomy."

The author of this paper after fairly stating this difficulty in the case of known methods of proof, proceeds to develop his method, which calls for the use of the spectroscope, which he claims, proves the point that is declared impossible of proof.

His first point is that the motion in double-star orbits is planar. Although there are many laws under which a body may describe a conic, of all these the Newtonian is the only one which has the star in the focus.

"To ascertain whether the star systems obey the law of 'inverse squares,' it is only necessary to determine the inclination of the orbit upon the line of sight, for this will enable us to decide whether the star is in the real focus of the ellipse," and the spectroscope is the instrument adapted to this kind of observation, consequently the author claims that method (the details of which are not here given) is established as generally a competent one.

The Relations of Men of Science to the General Public, was the title of the address of T. C. Mendenhall, as retiring president of the American Association of the Advancement of Science, at its annual meeting in Indianapolis for the year 1890. The main points of his theme were:

1. The particulars in which scientific men fail, as exponents of science among their fellows. Under this head is named with proper qualification, the fact that such men are sometimes unable, or unwilling, to present the results of their labors in form intelligible to intelligent people.

2. Men of science are liable to fall into the error of assuming superior wisdom as regards subjects outside the lines of their specialties.

3. Men of science are not always reasonably free from egotism in matters relating to their specialties, particularly in reference to authority and attainments in the same.

4. Another element of weakness in scientific men, is that they are often less "practical" in their work than they should be. Sometimes they even despise the useful and practical in science, and their dignity is disturbed when an honest and innocent layman asks what the use of this or that discovery is. This we deem one of the most important points of the address, because the fault is so commonly noticed and spoken of by intelligent laymen. We have ourselves been recently ashamed of some of our prominent scientific men for grevious errors in this way.

5. The last point of the paper is the demand which the public may justly make upon the man of science, that his interest shall not be less in public affairs than that of other men. The paper as a whole, is well calculated to call the attention of scientific men generally to a line of usefulness and an opportunity for good not duly appreciated heretofore.

Photographic Notes. "Professor Pickering, basing his conclusions on a series of photographs of the planet Mars, concludes that the southern temperate regions of Mars have just experienced an irruption of Polar ice."—*Photographic Times.*

Mrs. M. Fleming is constantly increasing the number of known variable stars through the careful examination of the Harvard College stellar photographs.

"Dr. J. C. Kapteyn, in the course of his measurements of the photographic plates taken at the Cape Observatory, has looked carefully for any difference of photographic magnitude of the same star on different plates, which might indicate variability, with the surprising result that up to the present he has found nine cases of possible variability—in one of which the body is already a known variable. . . . It is interesting to compare this result with that announced by Mr. Roberts to the Royal Society on 1890, Jan. 23, when he considered that at least ten stars in a single photograph showed signs of variability. The cases are not strictly parallel, for Mr. Roberts deals with much fainter stars, and those in a position of the heavens which is to some extent *sui generis*, viz: the neighborhood of the Orion nebula."—*The Observatory.*

Mr. William Huggins and Mrs. Huggins have recently published two papers of photographic interest. These papers are, Note on the Photographic Spectrum of the Great Nebula in Orion and On a New Group of Lines in the Photographic Spectrum of Sirius.

Rigel and the Great Nebula. Students in astronomy were startled with the announcement, not long ago, that probably nearly the whole constellation of Orion, would prove to be parts of one immense whirlpool nebula, having the great nebula of the sword as the most prominent center of condensation. In an article written by Miss A. M. Clerke, the leader of the October *Observatory*, several facts of interest concerning the relative positions of the stars and the nebulæ are grouped together, some of which are the following:

1. It is certain that stars and nebulæ co-exist in sidereal space, but by no means is it certain that they co-exist indiscriminately everywhere.

2. All nebulæ with which exact astronomical acquaintance has yet

been made are sensibly immobile, unless indeed those attached to the stars of the Pleiades rank as an exception, and (it ought to be said in addition) the few nebulæ which have been observed for motions in line of sight.

3. The nebular relationship of the star Rigel in the constellation of Orion is quite conclusive, as determined by the studies of Father Secchi, Dr. Scheiner's photographic researches; Herschel suspected it. Dr. Gill's parallax offers favorable suggestions, Dr. Auwers' studies, also of proper motions, while Vogel's spectroscopic determinations and Pickering's photo_ graphic work all offer useful contibutions to the great nebulous system of Orion.

4. What is the motion of this great system if anything like uniform motion exists there? The spectroscope must be appealed to for a careful and thorough examination of the parts of the system, and it seems that definite and prompt answer may be given by the aid of this instrument.

Dark Transit of Jupiter's Third Satellite. September 2d, 7^h 43^m, 90th M. T. I turned my 5-inch telescope with power of 120 upon Jupiter and saw what appeared to be the shadow of a satellite on the lower belt and near the center of the disc of the planet, and on referring to the ephemeris I found it to occupy the position of satellite No. 3. A steady look showed it to be a jet black dot which I was unable to distinguish by appearance from a shadow. On applying the 200 power E. P. fifteen minutes later the image appeared elongated transversely with the belts (north and south).

I observed it closely during the remainder of transit, could detect no change during the entire time until within eight minutes of egress when the inky black became less intense. On the satellite's emerging and with the dark sky background, it appeared with its usual brightness.

Definition fairly good.

Lat. + 38° 29′, Long. 85° 45′.

Charlestown, Ind. WILLIS L. BARNES.

Recent Longitude Determinations. During the past few months the longitudes of the following points have been determined by the telegraph method by the U. S. Coast and Geodetic Survey:

Helena, Montana.
Bismarck, Dakota.
Minneapolis, Minn.

Salt Lake City, previously determined, was used as a base.

The following additional points are now being determined from Washington, D. C., as a base:

Augusta, Georgia.
Gainesville, Florida.
Jacksonville, Texas.

Assistant C. H. Sinclair of this service, was in charge of the party executing both series of determinations. T. C. M.

Publications of Washburn Observatory. Parts I and II of Volume VI have been received. Part I consists of observations with the Meridian Circle by Alice Maxwell Lamb and Milton Updegraff, assistants

in the Observatory, of a list of over fifty stars. Individual observations are given for both co-ordinates. The purposes for which this list was observed were: (1) For use in determining the latitude of Washburn Observatory by the zenith telescope; (2) Observations of comparison stars of planet 181 *Eucharis*; (3) Observations of stars of a refraction list, and (4) Observations of zero stars from the Berlin Jahrbuch.

The second part consists of observations of double-stars by George C. Comstock, Director of the Observatory. In the introduction to this part will be found a full discussion of points of interest pertaining to the 15½-inch equatorial by Clark, the methods of observation, and the star places of certain star catalogues under consideration. This catalogue of double-star measures covers ninety pages in which individual observations of distance and angle are given, each having an average of about four observations.

Polaris and Companion. In accordance with the suggestion of the MESSENGER to amateurs to keep watch of the companion to Polaris, I have made a few observations during the past week, which clearly seem to indicate a very perceptible change in brightness, as compared with neighboring stars. The comparison stars used are shown on the following diagram. The stars *a* and *b* are on the Durchmusterung of Argelander. The telescope employed is a 3¼ inch achromatic. Powers used were 30 and 100.

My notes show as follows (the compa nion being indicated by v):

	h	m	
October 10	8	42	*a o v*
October 12	9	03	*a 2 v 1 b*
October 18	8	30	*b 2 v 1 c*

As I have been engaged in variable star observatious for the past six years, and have been in the habit of estimating in tenths of magnitudes, I do not think that the above differences can be entirely due to the errors of observations, but, of course, many more observations will be necessary, in order fully to establish the supposed variability.

Madison, N. J., 14 Oct., 1890. JOHN H. EADIE.

Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac. Part V of Vol II is a discussion of observations of the Transit of Venus in 1761 and 1769, by Simon Newcomb. The second chapter gives the observations of the transit of Venus, June 5–6, 1761, following the order of Encke's list of stations and references, as given in the opening part of each of his works. The third chapter presents the observations of the transits of Venus, June 3, 1869, as obtained from the same sources and a few others named. The fourth chapter discusses the geographical positions of the stations, the fifth, tabular elements to be cor-

rected by observation; the sixth, tabular summary of observations and their comparison with the tabular times; seventh for formation and solution of the equations of condition, and the eighth, discussion of result. The final result reached for the equatorial horizontal parallax is 8″.79 ± 0″.051 or ± 0″.034; the first error being mean, and the second probable.

This discussion also brings out a correction to LeVerrier's latitude of Venus at descending node for mean of 1761 and 1769 of + 1″.915 and a correction to LeVerrier's longitude of node for 1765.5 of + 32″.4.

The first chapter of this paper is a general introduction, in which its author notices the changes of opinion on the value of observations made on the transits of Venus in 1761 and 1769, and probably the wrong tendency to adopt the values of astronomical constants obtained during the last century instead of results obtained by a judiciously weighted mean of all previous determinations. The solar parallax affords a case in point. In 1854 Hansen's value by the parallactic equation of the moon made Encke's value of the parallax decidedly too small. But Hansen's definitive determinations in 1862–63 were 8″.916 and Foucault's from the velocity of light was 8″.86, while that by Stone and Winnecke was respectively 8″.943 and 8″.964. The result of these investigations was to reject Encke's result entirely, whereas, if all these results and others known had been judiciously combined, such a weighted mean would have been, as we now know, much nearer the true value. For, Professor Newcomb says, it would have changed the final result of his own discussion in 1867 to a value probably somewhere between 8″.79 and 8″.82. There are several other interesting points in this discussion that deserve notice in this connection but space at present forbids.

Orbit of Delta Cygni as computed by J. E. Gore gives the following elements.

$P = 376.659$ years	$\Omega = 98° \; 40'$
$T = 1914.16$	$\lambda = 175° \; 7'$
$e = 0.327$	$a = 2''.39$
$i = 41° \, 26'$	$\mu = -0.9957$

The computed position-angles compare well with the observed ones since 1783.

President Lewis McLouth, of the South Dakota Agricultural College, has decided to build a small Observatory for that institution. He is now in correspondence concerning the instruments.

Professor Bacon, of Smith Observatory, Beloit College, has been granted a short leave of absence on account of ill health.

The Photographic Chart of the Sky. The fifth part of the Bulletin of the Permanent International Committee has just come to hand. From the announcement of the President of the Committee, Admiral Mouchez, we learn that 10,000 francs have been donated by M. Bischoffsheim, for the construction of apparatus for measuring the photographic plates. The next meeting of the committee is called for March 31, 1891, at the Observ-

atory of Paris. Most of the Observatories are ready to begin work, and the work will be begun immediately after the meeting of the committee in March, 1891. The Bulletin contains papers by Messrs. Holden, Schaeberle, Lindemann, Common, Turner, Christie, Trepied and Pickering, and correspondence between different members of the committee.

Of late we have had a number of inquiries for small second-hand telescopes. Those wishing to sell good instruments with apertures from three to six inches are requested to inform us of the fact, and we will be glad to name the persons desiring such instruments.

Publications of the Astronomical Society of the Pacific. Number 10 of Volume II comes to hand just as we go to press with the last form of this issue. The articles of this number are, "Drawings of the Moon," by Professor Weinek, "The Age of Periodic Comets," by Daniel Kirkwood, "Notes on Astronomy in South America;" "Corrigenda to v. Oppolzer's Lehrbuch zur Bahnbestimmung der Kometen und Planeten;" "A Suggestion of a Way to Forward our Knowledge of the Asteroids;" "On Photographs of the Milky Way made at the Lick Observatory in 1889, pp E. E. Barnard. Under the head of Notices from the Lick Observatory the following appear:

That the rotation time of Venus is thought to be, by the observations of Schiaparelli, 224.7 days, the same as its time of revolution around the sun.

That some rather singular black spots are observed just within the north edge of the north equatorial band of Jupiter. These were exactly like the shadows of the satellites for which they were first mistaken. One of them is situated near the red spot.

That an interesting phenomena of bright spots projecting beyond the terminator of Mars was observed by the aid of the 36-inch refractor on the night of July 5 and 6.

That a black transit of the IV satellite of Jupiter was observed Aug. 13, 1890, at the Lick Observatory, by the aid of the 12-inch equatorial by E. E. Barnard and J. M. Schaeberle. It appeared black and perfectly round. It was some distance preceding two of the singular small black spots on the north edge of the equatorial belt, and about in the same latitude. The surface of Jupiter rotating faster than the apparent motion of the satellite caused the small black spots to overtake it, and the preceding of the two was seen to catch up with, and pass behind, the satellite, and finally to emerge on the preceding side of it. When about three-quarters across the disc of Jupiter the satellite had a slightly brownish tinge (reddish black), but later this slight tinge of red disappeared, and the satellite was of a cold black color. The most singular view was near the end of the transit. It became smaller as it approached the limb, and seemed extended slightly north and south. It did not appear to lose its blackness as much as it did its size. Finally it was a very small black speck, and not yet in contact with the limb. A little later a small portion of its disc was seen protruding beyond the edge of the planet, and when nearly half off this portion did not appear round, but wedge-shaped. As the satellite emerged that part remaining on continued black, while the portion off the disc was as bright

as the adjacent part of the planet. The dark part seemed to be left behind, and to shrink into smaller and smaller space on the disc of the satellite as it emerged, until the blackness entirely disappeared. When fully off the disc of Jupiter, the satellite appeared small, and of a uniform pale ashy tint. As compared with Satellite I, which was near it and preceding, it was not over one-fourth as large as that satellite in diameter, and many times less bright.

In another note Professor Holden offers the suggestion that the parallax of nebulæ may possibly be studied successfully by the aid of photography. The suggestion is, by suitable device the exposure time may be so reduced, that the nebula may be made to give an image upon which perfectly precise measures of position can be made. Now if a series of such negatives made with exactly the same exposure times, were continued throughout the year, it is believed they would afford suitable data for the determination of parallax.

We are glad to notice that the Lick Observatory has recently become the recipient of a gift of an electric lighting plant by the Edison General Electric Company, of Orange, New Jersey. That generous gift was presented September 4 and consists of a complete plant of steam engine and boiler, dynamo, belting, main wire, controlling wire and a set of storage cells in duplicate—the whole as a free gift.

BOOK NOTICES.

The Elements of Plane and Solid Geometry, with Numerous Examples. By Edward A. Bowser, LL. D. Professor of Mathematics and Engineering in Rutgers College, New York. D. Van Nostrand Company, Publishers 23 Murray and 27 Warren Streets. 1890, pp. 393.

In writing this book the author has aimed to combine the excellences of Euclid with those of the best known modern writers, retaining the syllogistic form of demonstration, but re-arranging the order of matter somewhat, and making such changes in the demonstrations as seemed to him to be either necessary or desirable. Teachers of experience know that Euclid's treatment of the angle is deficient, and that his arrangement of propositions is poor because of a lack of systematic classification of themes that the logic of mathematical thinking ought to bring out. It is in this line, perhaps, more than any other, that modern books on geometry are improvements on the work of the renowned old Greek geometer; and this work is a contribution in the same direction. In Book one of the Plane Geometry the first proposition is, "All straight angles are equal to one another." At first reading such a proposition seems novel, and scarcely necessary to the completeness or integrity of the course desired, and yet under preceding definition it is admissible.

The form of demonstration employed is brief and compact by the free use of symbols, and the exercises that follow the themes, and the notes that are frequently interspersed, are desirable features in this text-book. The matter is about the same as that which will be found in most of the good text-books on the same subject. The whole subject is divided into nine books, the Plane Geometry being treated of in the first five instead of six as is the common way.

Father Perry, F. R. S., The Jesuit Astronomer. A Sketch of his Life, Work and Death by Aloysius L. Cortie, S. J. London. The Catholic Truth Society, Publishers, 21 Westminister Bridge Road, S. E., pp. 113. Price One Shilling.

It will be remembered that this journal gave a full 'page frontispiece plate of the late Father Perry in its May issue which also contained a brief biographical sketch of his life,

In the neat little book before us a much fuller account of his life, work and death is to be found, with illustrations of such phases and incidents of his work as would naturally interest the reader. A good half-tone plate of Father Perry is made the frontispiece, then follow pictures of Stonyhurst College, the Observatory, the telescopes used for solar work, enlarged sunspots, maps showing the places visited by Father Perry in his scientific journeys, lakes to the south of Observatory Bay, a group of natives of the S. W. of Madagascar, the "Coronagraph" at Sault, with Father Perry, Capt. Atkinson and Lieut. Thierens in the last expedition, and a full page view of the corona of sun as photographed by Father Perry, Dec. 22, 1889. a full, appropriate and an unpretentious statement of the leading facts of a very worthy life. It is a book for the genreral libary.

The Pathway of the Spirit. A Guide to Inspiration, Illumination and Divine Realization on Earth, by John Hamlin Dewey, M. D. New York: Publishers, Frank F. Lovell & Co., 142 and 144 Worth Street. pp. 300. Cloth, gilt, $1.25.

This book is the second by the same author in a series called "Christian Theosophy Series," the first being "The Way, the Truth and the Life." In presenting the theme, "The Pathway of the Spirit," the author divides it nto two parts: (1) Immediate inspiration and knowledge of God, the supreme necessity and universal possibility of man. (2) Inspiration and divine illumination: their special nature and distinguishing characteristics. To establish the first point the author shows the necessity of God-knowledge; that moral sense is rooted in divinity and is not expediency, that man must have direct intercourse with God, that the Kingdom of God is the Kingdom of truth and righteousness, and that truth pertains to a knowledge of all things, and of our relations to them, spiritual and physical; and that righteousness is the right use of this knowledge and of our powers in its pursuit, and that the throne of power and government is within and yet above the soul; that Adam and Christ are representative types of character and both possible to man, Adam presenting the natural man subject to temptations of the sensuous life, and Christ the spiritual man in unity with the father, and that the best in both are possible to man in this life, on earth, if he will overcome on the one side, and win and possess that which is offered and within reach on the other. In speaking of "the fall," we notice that the author treats the Garden of Eden as a story for the illustration of truth, and not as a historical fact, and that under the head of "Revelation opens equally to all," he holds that authority is not in the book we call the Bible, though it contains never so much of truth in external statement, but in the unwritten word of God, in the soul that recognizes and receives it." That probably means that the author does not believe in plenary inspiration. Professedly the author is not a materialist

nor a pantheist. He is a theist and a believer in Christ. Under the paragraph entitled, "The Key to Missionary Success," the statement is made that "the appeal must be made directly to the authority and word of God in each soul," and that, in using the scripture, the lives of inspired men and the words of inspired men recorded in all true scripture, should be pointed to for example, instruction and encouragement in the way of life, not as arbitrary authority.

As a whole, the first part of this book is a discriminating and generally a careful statement of the leading facts about immediate inspiration and knowledge of God, and the supreme necessity and universal possibility of man in a general sense, but little, scarcely anything, is said about sin and its direful consequences. The motive of love in this higher life is, of course, the greater one, but the dreadful fact of the ruin of sin in this world is left wholly out of sight as a motive, or a factor in operation. The Bible is very explicit on this point as well as the other.

When we come to carefully read the second part of this book concerning the nature and distinguishing characteristics of inspiration and divine illumination, we find considerable food for thought. What is said of mind cure, physical healing, Christian science, white magic, etc., is doubtless true but we are not sure that evil is but the perversion of good, and therefore has a beginning and an end. Nor do we believe that because "love and goodness" exist, universal redemption is assured; nor that "Our Father in Heaven," in the Lord's Prayer, is thought of by the lost now, or ever will be, as a meaningless "character." Does not the truth rather lie in the fact that the lost will call on the rocks to fall on them and hide them from the wrath of the Lamb. The Devil is not the dark shadow of the Lord's glorious presence, neither is the cry of Dives for mercy an unfinished prayer rarified to infinitesimal tenuity by the possibilities of a second probation. It also seems that the author's ideas of evolution are of such a harmless kind that they do not give much complexion really to his belief in and statements of the new theology to differentiate it from the old doctrine. Of course nothing is longer said by the new school people, on spontaneous generation, nor very much about the origin of species. The searching tests of the truth in the last few years are reducing these theories to proper level and expunging all mischievous errors. We do not undervalue this book by these references. It has much truth in it, and an inspiration for the reader that he will probably never forget. The stimulus is worthy and wholesome and its spirit is progressive and uplifting.

Imperial Observatory at Rio Janeiro, Brazil. Tome IV, parts 1 and 2 of the *Annes do Imperial Observatorio do Rio de Janeiro* have been received. The first part is a neatly printed quarto volume of 123 pages, containing an extended introductory paper on the distribution of the group of planetoids between Mars and Jupiter. This paper is by E. Liais and L. Cruls and is accompanied by a full page plate, showing, in colors, groups of orbits of nodal points. Then follows a discussion of the observations of the transit of Mercury on May 6, 1878, the transit of Venus, 6 Dec., 1882, and a list of measures of double stars. The second part is devoted to meteorological records from 1883 to 1885 inclusive, and is a large volume of 406 pages.

THE SIDEREAL M...

CONDUCTED ...

DIRECTOR OF CARLETON COLL...

VOL. 9, NO. 10. DECEMBE...

ON THE PROPER USE OF A H... PORTABLE ...

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THE SIDEREAL MESSENGER.

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, NO. 10. DECEMBER, 1890. WHOLE NO. 90

ON THE PROPER USE OF A HANGING LEVEL ATTACHED TO A PORTABLE TRANSIT.

T. H. SAFFORD.

For THE MESSENGER.

It is now thought, by the best instrument makers, that a portable transit should have a reversing apparatus and a hanging level. The two features (in connection) fully make up for their weight and complexity by the smaller dimensions which can be given the whole instrument without sacrifice of accuracy; so that, as I have had occasion to notice, a small instrument thus constructed gives more accurate results than a larger one made with less intelligence.

But the hanging level should never be reversed by hand while astronomical observations are going on. The striding level, or any level, loses greatly in effectiveness when it is much handled; the change of temperature caused by the contact with the hands, and the slight jar which it receives when it is set down, are enough to alter the zero-point; and the results of experience show that this changes quite slowly and continuously when the level is undisturbed.

If, on the other hand, the reversing apparatus performs its work perfectly it will let the level down, along with the pivots, far more easily and smoothly than can be accomplished by the observer's hands; at any rate as carefully as the instrument itself is set down.

Professor Döllen, of Pulcova, a very thorough investigator of portable instruments (he has trained in their use many Russian geographers) has studied this question with great care. His paper, published in 1874, seems to be very scarce; I have tried in fact without success to buy it, and will therefore give an abstract of its results, so far as they relate to the use of the level, from a borrowed copy. He made

an extensive series of levelings both ways; first by reversing the level between the two readings of each pair, and lifting it between the pairs; and secondly by reversing the instrument (level and all) with the apparatus between the two readings of each pair and reversing the level on the pivots only *once* for about 30 readings.

By the first method he obtains directly the difference of level of the *tops* of the two pivots, as astronomers most commonly do. By the second method the pivots themselves are joined with the legs of the level, and the direct result is the difference of level of the points on the Ys where the pivots rest, or that of the *bottoms* of the pivots.

In the first case the difference (if any) of the diameters of the pivots appears in the differences of level, but not in the zero-points of the level itself, for the latter values are independent of the absolute difference of level of the points where the level is supported. In the second case there is no difference of level of the instrument caused by the reversal, for the frame is fixed, and the points determined are on the frame. But as the level goes with the pivots, any difference between these would be added to any difference in length of the arms (or legs) of the level and so affect its zero-points. In order to eliminate this the level may be reversed by hand on the pivots, but from time to time only, and with great care; and never in connection with astronomical observations.

When, for instance, arrangements have been made for a telegraphic longitude compaign, it is very wasteful of labor to combine any needless investigation of the instrument with the evening's work upon the stars. The difference of diameter of the pivots can be determined on any half-hour of a rainy day, and with a good level and good reversing apparatus, almost by any student and certainly by anybody fit to be a recorder. And this determination can be repeated half a dozen times while other preparations are going on. But, with a known difference of pivots, any reversal of the instrument gives an accurate level-zero, and it is a very simple thing to reverse the instrument and determine this zero even while one is waiting for star work to begin or for a telegraph operator to make himself heard at the other station.

But, while the stars are passing, it is an additional needless strain upon the nerves to reverse the level by hand. It is illogical, as one great reason for using a reversing apparatus at all (with a light instrument) is to reverse the level along with the transit.

The following is a series of observations of the difference of diameter of the pivots of our small portable transit by Wanschaff. It has a 2-inch aperture, a "broken" telescope, a hanging level, and reverses with the help of an eccentric (not a gearing, as in the Russian transits) in a very few seconds. The observations were made on separate days during the last term of 1889-90, mostly in connection with students. The first seven determinations comprised sixteen readings, the last eight each; these latter were given half weight:

Date.	Lamp Pivot Thicker by	
March 27	0″.75	
31	0 .80	
April 22	0 .76	
22	1 .35	(Another observer)
25	1 .14	
May 2	1 .16	
5	1 .04	
June 23	1 .98	Half weight
27	1 .19	"
28	0 .99	"
Mean (wt 8½)	1″.07 ± 0″.067	

Probable error of one determination (wt = 1) ± 0″.19 by series of errors, ± 0″.20 by series of squares.

Now, as the correction to be applied to the observed level is only one-fourth this amount, it will be seen that these ten determinations give the correction:

$$0''.27 \pm 0''.017$$

surely accurate enough.

It is, however, extremely difficult to observe the level as accurately in the night as was done in these daylight observations. Why it is so I do not know; but there are several causes which may affect the matter. First, the daylight work was usually done on cloudy, even rainy, weather. when out door work with instruments was impracticable. Hence the temperature was unusually even, and the shutters being closed, no draughts affected the level. Moreover, as nothing was then to be done except make these pivot measurements, they were very leisurely made and carefully timed.

But, as a result, it is very clear that the trifling difference of pivots, whose effect on one-sided time determination is only $0''.27 \sec\varphi$ (or for Williamstown, after reduction to time, only $0^s.025$) can readily be applied to level-readings when the level and instrument are reversed together, and without any loss of accuracy; so that the observer will gain greatly in peace of mind, if not in anything else, if he keep his hands off his level during a time-determination. But for this he must have a level which does not need to be taken off when the telescope passes the zenith. There are two such constructions; the telescope in the first is straight but the level arms long enough to allow the eye-piece to pass; in the second, as in the Williamstown (and Cambridge) transits the telescope is "broken." Most young observers are apt to hurry; not to lose stars they think important. The Russians, who have nearly perfected the practical astronomy of portable instruments, adopt the opposite course. They make their working lists with extreme care, using a few stars only, and allowing time enough between them for the most deliberate judgment as to every point observed; but in this way the observers' nerves are kept in the quietest and best condition, and the observations are not apt to be unexpectedly and abnormally discrepant.

Let me give a programme made up on these principles. I propose to determine time about $23^h\ 35^m$ of sidereal time, using γ Cephei as a polar, and reversing upon it. I will allow about 12 minutes for it—from $23^h\ 29^m$ to $23^h\ 41^m$—and precede it by two stars, and follow it by two more.

The programme will then be:

$23^h\ 12^m$	Read Level at Zenith.
13	Reverse Instrument.
15	Read Level.
19	υ Pegasi—Read Level.
23	70 Pegasi—Read Level.
27	Set on γ Cephei—Read Level.
29	γ Cephei, 4 wires—Read Level.
34	Reverse Instrument.
35	Set on γ Cephei—Read Level
37	γ Cephei, 4 wires—Read Level.
47	φ Pegasi—Read Level
52	ψ Pegasi—Read Level
56	Read Level at Zenith.
57	Reverse Instrument.
59	Read Level.

or, in all, 48 minutes for six observations; counting the polar in reversed positions as two observations. We have now three reversals of the instrument which certainly take no more time than so many reversals of the level alone; twelve level readings each of which can be accomplished in a few seconds; and there is no need of waiting for the level to settle after reversal during the time observations; the first reversal takes place while the observer is getting his tools into order for work; the second while the polar is passing, and the third while he is closing up or resting at the end of the group.

Now in Döllen's series of levellings, before mentioned, the difference in accuracy of the two methods is altogether in favor of reversing the level with the instrument, and not without. It is true the probable error in either case is very small, so that practically there is but little difference; but two complete levellings or four scale readings, when the instrument is reversed, are full as good as twice as many by the ordinary method; what really is of importance is the saving of time and nervous strength by avoiding the reversals of the level by hand.

I will conclude by adding a brief statement of the views here presented.

1. Every portable transit, large enough to have a reversing apparatus, should have a hanging level.
2. This level should have arms long enough to clear the eye-piece in passing the zenith.
3. It should never be reversed by hand during astronomical observations, but turn always with the instrument.
4. The difference of pivots should be obtained by special operations, with closed shutters, in cloudy and rainy weather.

The title of Döllen's paper to which I have referred is:

"Die Zeitbestimmung vermittelst der tragbaren Durchgangs instrument im Verticale der Polarsterns." St. Petersburg, 1874.

Williams College Observatory, October 29, 1890.

THE RADIANT POINTS OF METEORS.

W. F. DENNING.

FOR THE MESSENGER.

Mr. W. H. S. Monck, in essaying to discuss my catalogue of meteoric radiant points, assumes a position which the extent of his experience does not qualify him to fill. He entirely lacks a practical knowledge of the subject. The result is that his deductions are wrong and his statements misleading. Mr. Monck says that I "seldom if ever, watched through an entire night," whereas, in point of fact, I have made observations during hundreds of entire nights! For this and other misstatements your correspondent has no authority whatever, and I am surprised that his desire for notoriety has so obviously out-weighed his discretion.

Mr. Monck has questioned my conclusions by writing to *Nature*, *The Observatory*, *The English Mechanic*, and has privately published a pamphlet in which his adverse criticism is reiterated. In some of these writings he shifts his position; finds that his ideas cannot be "maintained any longer," and is evidently himself perplexed as to what he does and does not believe. One thing, however, has clearly exercised a paramount influence over him, and that is the desire to give the world the benefit of his opinions on a matter which he has never studied in its practical bearings.

With reference to the shifting radiant point of the Perseids your readers may accept it once and for all, as a fact convincingly proved by adequate observation. I have watched this fine shower at its annual returns since 1867, and the easterly motion of the radiant is one of the most certain features I have ever noticed respecting it. Mr. Booth, an able meteoric observer of Leeds, has partly confirmed my results; and when further observations are accumulated I have the greatest confidence that the peculiarity I discovered in 1877 will be fully verified and universally accepted as one of the demonstrated facts of astronomy.

Mr. Monck in drawing his inferences has simply had the published figures to work upon. He does not appear to have considered the relative strength of the various showers, nor could he know the degree of accuracy of the individual radiant points. And there are many other features which,

though familiar to the observer, and by him given their proper weight, are not apparent in the tabulated results—though such details must aid him materially in discriminating aright, they are yet beyond the cognisance of the mere critic who has nothing but a superficial knowledge which is not much good to him, for the facts are very complicated and easily liable to misconception. It is only a thoroughly practical acquaintance with meteors derived from many years of close observation that can enable a man to arrange and group the radiant points in a satisfactory and reliable manner.

I think Mr. Monck is indiscreet in subjecting observers to harassing attacks. His energy might be better applied. Our observations are effected in the hope that they may be useful in elucidating doubtful points and accelerating in some small way the progress of the science we love. Our chief aim is to make reliable observations, and to interpert them correctly. If Mr. Monck thinks that by picking out a few figures from a mass of careful results he can subvert the deductions of the author of them he is greviously mistaken. He may annoy and embarass observers whose hands are already full of work in the delightful field of observation, but he will never shake their integrity or detract from the value of their discoveries. No observer can object to legitimate criticism as this has a tendency to remove anomalies and sometimes gives effect to observations, but mere quibbling is to be deprecated and can certainly never exert any useful influence.

My meteoric observations must stand or fall according to their merits as determined by future observers. Their value cannot be affected by criticism of the kind applied by Mr. Monck. We need facts not inferences. I hope it is not too much to say that I have the utmost confidence in my results.

BRISTOL, ENGLAND, Oct. 15, 1890.

DR. CHRISTIAN HENRY FREDERICK PETERS.

J. G. PORTER.

For THE MESSENGER.

On the morning of July 19th Dr. C. H. F. Peters, director of the Litchfield Observatory of Hamilton College, was

found dead upon the door step of the college building where he lodged. His observing cap was on his head and a half burned cigar in his fingers. It is presumed that he was struck down by apoplexy while on his way to the observatory to commence his nightly work. Thus has passed away at the ripe age of seventy-seven one of the most distinguished of our American astronomers. He was a Dane by birth, but pursued his studies at the University of Berlin, taking his degree there in 1836. The next few years he spent in Italy, taking part in the survey of Mt. Etna and other geodetic and astronomical work. Upon the breaking out of the revolution in 1848 he joined the forces of Garibaldi and was speedily promoted to the rank of Major of Artillery. He was twice severely wounded. After the failure of Garibaldi's movement Dr. Peters was forced into exile and spent some time in Constantinople. A few years later, at the suggestion of U. S. Minister George P. Marsh, he came to this country, and after a brief connection with the Coast Survey and the Dudley Observatory, was called in 1858 to the directorship of the Litchfield Observatory then just established. His great ability and wonderful industry soon gave the Observatory an acknowledged rank among the scientific institutions of the country.

One of the earliest contributions which he made to astronomical knowledge was a series of sun-spot observations extending through about twelve years and thus embracing the whole of one cycle of variation in solar activity. His celestial charts are well known. Besides the twenty already published many more are nearly or quite completed. The zone observations which form the ground work of these charts number over 100,000. It was Dr. Peters' intention to publish a catalogue of these star positions in connection with the charts. Upon the group of minor planets he also expended a vast amount of labor. Forty-eight of these bodies were first discovered by him at the Litchfield Observatory. The investigation of their orbits, by no means a light task, was usually undertaken by the Doctor as a recreation after his more arduous duties. He was often called upon to determine geographical positions. The northern and western boundaries of New York state, as well as many places in the interior, were fixed by him.

In 1869 he was enabled through the liberality of Mr. Litchfield to organize a party to observe the solar eclipse at Des Moines, Iowa, and in 1874 he was appointed chief of the U. S. Transit-of-Venus expedition to New Zealand. The remarkable success of his party was a source of much gratification to him. Upon his return a public reception was tendered him in Utica, which was made the occasion of the presentation of a fine pocket chronometer.

Notwithstanding the almost incredible amount of astronomical work that Dr. Peters, almost single-handed, accomplished during the thirty-two years of his directorship, he was by no means a man of one idea. For wide and accurate knowledge in nearly every field of science, and for general intelligence on the topics of the day, he had few equals. His linguistic attainments were unusually great. Latin and Greek were as familiar to him as his native tongue, and he was at home with nearly all the modern languages of Europe including Turkish and Arabic. The knowledge of this latter language he put to good use, having been engaged for some years prior to his death upon the important task of re-editing Ptolemy's Almagest. During recent trips to Europe, several manuscripts hitherto unknown were discovered by him in the libraries of France and Italy.

In 1887 Dr. Peters was a member of the convention of astronomers assembled in Paris to inaugurate the photographic survey of the heavens, and the high distinction of the decoration of the Legion of Honor was then bestowed upon him by the French Government. For many years he has been a member of the National Academy of Sciences as well as of other learned societies at home and abroad.

Personally Dr. Peters was a man of the highest integrity and honor, courteous in his bearing, kind and generous to all. To those who manifested any desire to understand the subject of astronomy he was a most patient and painstaking instructor. He was never married but possessed a social nature and a certain gentle refinement which made him a favorite in the family circles of College Hill. His death, though sudden, was probably painless, and found him, as he doubtless would have wished, in the midst of his accustomed labors. The world-wide fame which he has justly won is due not to transcendent genius or brilliant

episodes, but to faithful, diligent toil and life-long devotion to his chosen profession. His career of usefulness and honor may well be an encouragement and a stimulus to us who are seeking to follow him up the ever ascending pathway of science.

HOW TO MEASURE THE INVISIBLE.*

HENRY M. PARKHURST.

Continued from page 413.

The general laws of optics are most readily understood when light is conceived of as an emanation of particles. But investigation has shown that this is not its true nature. It really consists of vibrations, or waves, or modulations; and it is necessary to take that view of it in order to understand the phenomena I am about to explain.

Waves of light consist of alternate condensation and rarefaction of the ether. It is stated in the books that the different kinds of light move with the same velocity, but that the wave-lengths, or the distances between the points of greatest condensation, vary. The shorter the wave-length, the more is the ray affected by a refracting medium. This is a fundamental principle; and I think a few suggestions, founded upon facts within our own observation, will be sufficient to establish the principle that the extreme red and the extreme violet rays of light move with the same velocity.

For convenience I will assume that if there is any difference, the violet rays move more rapidly than the red; since with equal wave-lengths the extreme violet rays would move nearly twice as fast as the extreme red. In a total eclipse of the sun, when the sun emerges from behind the moon, all the rays start from the moon's edge toward the earth at the same instant. If the violet rays moved most rapidly, they would reach the earth first, and the first glimpse of the sun would be an intensely violet streak of light. For the same reason, the last glimpse of the sun before the totality would be an intensely red streak of light. No such difference has been noted. But as the difference is

* A lecture delivered before the astronomical department of the Brooklyn Institute, October 15, and illustrated with lantern views and diagrams.

only for the gain of the violet rays in the distance from the moon to the earth, which the light traverses in little over a second, the time during which the effect would be visible would be but a fraction of a second.

Let us take then an eclipse at a greater distance. When the shadow of the first of Jupiter's satellites falls upon its disk, it takes forty minutes for the light to reach us. If the violet light moved twice as rapidly as the red, there would be red rays still reaching us for twenty minutes after the violet rays had been cut off. During those twenty minutes the shadow would have moved over one-seventh of Jupiter's diameter. There would therefore be a fringe of red light next the shadow and following it, extending across one-seventh of Jupiter's diameter, gradually approaching whiteness. For the same reason there would be a fringe of violet light next the shadow and preceding it, for an equal distance. The fact that no color is observed, proves that if there is any difference in the velocity of the light of the two colors it is exceedingly small. We have still another test, more delicate still, although not resting upon so certain a foundation. If the diminution of the light of Algol arises from the interposition of a dark body, as seems probable, we have the distance between Algol and the earth, in which the different colors pursue their race; so that if during that distance either gained many minutes upon the other, it would become evident by giving to Algol a corresponding tinge during the latter part of the period of its minimum. In some variable stars a red light is seen; but to be produced by this cause it must be supplemented by an equally observable violet light; which has never been seen although carefully looked for. We may consider it demonstrated, therefore, that light of all colors moves with the same velocity.

The analogy between waves of sound and waves of light gives another illustration. If the same principle of more rapid motion for short wave-lengths were applied to music, the high notes would reach us sooner than the low notes; so that in listening to strains of music in the distance, the high notes would reach us a quaver or semiquaver too soon. Carrying it still further, at the distance of a mile the first line of Duke Street, "Lord, when Thou didst ascend on

high," going up the octave, would have its notes all reach us together; and upon going another mile all would be reversed, the high notes coming first, apparently descending the scale as in the tune of Antioch.

The mode of measuring the wave-length of the different colors, and the effect of wave-length upon refrangibility, I cannot well explain without diagrams, and will defer for the present. But there is one other preliminary suggestion I can make now.

The refrangibility of light depends upon its wave-length When a wave strikes a refracting surface, what determines the degree of the refraction? That wave passes along in its refracted course without waiting for the next wave. Each wave is refracted independently. My explanation is this: The force of light is divided between the different waves emitted within a given time. There being twice as many violet rays, each has but one-half the force of the red light, it is therefore more retarded by the denser medium, and for that reason bent farther from its course. The fact that red light has sufficient force to penetrate the mists of the morning and evening sky, when the violet rays are stopped, indicates the probability of the correctness of this explanation.

The retardation of waves of light by a refracting medium can be illustrated effectively, I will not undertake to say with how much accuracy, by comparing them with a person attempting to cross Brooklyn bridge at a time when it is so crowded that he is compelled to forget good manners and push his way by main force. The more dense the crowd the slower his rate of progress. The stronger he is the faster he can get along. The moment the way is clear he resumes a pace as rapid as before entering upon the bridge. So the waves of light, however much they are retarded in passing through a dense medium, do not lose their progressive force, as if they had been detained by friction, but, as shown by their outward refraction at the second surface of a lens, they pass onward with unabated vigor and speed.

It is an important consideration that the effect of a refracting medium does not depend upon the absolute wave-length, but upon the relative wave-length. We have an illustration of this with reference to the waves of sound, in the whistle of a passing locomotive. As it approaches us

the pitch is a little higher than it would be if stationary, and the moment it has passed, the sound becomes perceptibly lower while it is receding. To return to the bridge illustration, if the crowd is moving in the same direction with ourselves, we can get along much faster than if it is moving in the opposite direction. The fact that we are moving towards a star, does not increase the refrangibility of its waves by shortening their absolute wave-length, or by weakening their force. But it diminishes their relative wave-length, and it diminishes their power of progressing through the obstacle of a dense medium; and thus it diminishes their velocity, and this increases the refrangibility.

If we were to approach the sun with the speed of light, 200,000 miles per second, carrying with us a refracting prism, there would be twice as many waves striking the prism each second, which would make the relative wave length only one-half. The result would be that the extreme red rays, at the line A, would occupy nearly the position of the extreme violet rays, at the line H. If we were to approach the sun at 200 miles per second, the lines would be shifted only $\frac{1}{1000}$ as much, but in the same direction. That is, the line D^1 would nearly coincide with the line D^2. If then we were to find a fixed star in whose spectrum the sodium lines appear, and if upon comparing the position of its spectrum we should find its D^1 line to correspond with the D^2 line of the sodium flame, we should know that we were approaching that star, or it was approaching us at the rate of about 200 miles per second.

Here we reach the measurement of the invisible without making it visible; for there is no magnifying power which will enable us to see the motion of a star from or towards the earth. The only way it can become visible is by the enlargement of its disk when approaching us; and in the case of a star too distant to have a disk, of course this would be imperceptible.

This method has been applied to many stars, with varying results, indicating motions relatively to the earth, sometimes towards and sometimes away from us.

This method was recently applied to the star Algol, by Vogel. He measured the positions of the lines at different periods with reference to its minimum phase, and found that

before the minimum Algol was receding from us, and that after the minimum Algol was approaching us. He repeated these observations often enough to make it certain that the change of its motion was connected with its apparent brightness. Although he could not see any companion, it was evident that there must have been a dark companion with similar and opposite motion, the two revolving about a common center. He deduced certain results with regard to the masses of the two stars thus connected with each other; but there seems to have been introduced as a link in the chain of reasoning, more or less conjecture. I prefer, therefore, to pass on at once to another more remarkable discovery of the same character, which was made at about the same time by Professor Pickering at Harvard.

In photographs of Mizar, showing its spectrum, it was observed that some of the darker lines appeared double. At other times the same lines appeared single. By taking repeated photographs there was found to be a periodicity about this duplication of the lines, so that it could be predicted. What was the cause of it? Manifestly that the star Mizar, never seen optically as double in the most powerful telescopes, nevertheless is a binary star, the two components revolving around a common center of gravity in twice the period of the duplication of the lines. For calling the two stars A and B, when A is approaching and B receding, their lines will be separated by the difference of their relative motion; when A is nearest and B the most distant, neither will have any motion to or from the earth, and the lines will coalesce; then A recedes and B approaches, the lines again separating but being transposed from their former position; and finally A will be most distant and B the nearest, when the lines will a second time have coalesced. Since the duplication occurred every 52 days, it is manifest that the period of revolution is 104 days.

It will be noticed that the distance of Mizar from the earth has no relation to this duplication of the lines; it depends wholly upon the rate of motion of the two bodies, A and B, as compared with the wave lengths of the undulations of light. Were Mizar a million times, or millions of millions of times as far away as it actually is, the separation of the lines would be the same; all the difference would

be that being more distant the star would be fainter, and being fainter its spectrum could not be so easily seen. Were our sun to be gradually removed from Mizar, the lines would grow fainter and fainter until they disappeared, but the amount of their separation would remain uniform. Nor does the distance of the stars A and B from each other at all affect the separation of the lines. Were they a million times as far apart, moving with the same velocity, the separation would remain the same; or were they a million times as near together, moving with the same velocity, the separation would remain the same.

The first thing ascertained from these observations was the period of revolution. Next we have the actual rate of motion. The relative motion causing the division of the lines, is the sum of the motion of the two bodies. The two lines appeared equal in blackness, showing that the two stars are nearly equal in brightness; from which it may be inferred that they are nearly equal in mass. If so, the indicated motion of 100 miles per second is twice the actual motion of revolution. But as, by the laws of motion it makes no difference in what proportion the mass is divided between the two bodies, it will be most convenient to speak of one of the stars as stationary and the other in motion. We may now determine the size of the orbit; for if the motion is 100 miles per second in a circular orbit, and if it requires 104 days of such motion to complete the orbit, the circumference of the orbit must be about 900,000,000 miles and the distance of the two stars about 143,000,000 miles. This is but two million miles greater than the distance of the planet Mars from the sun, whose period is 687 days. As its actual motion is more than six times as rapid, revolving through the same distance in 104 days, the mass must be increased, to preserve a circular orbit, by the square of this ratio; showing that the mass of the two stars is about 40 times the mass of our sun.

A few additional and new computations, based upon the most available assumption of brilliancy, may be interesting. Dividing this mass between two stars of equal density with our sun, and of equal brightness of disk they would give about 15 times as much light. Adopting Sir John Herschell's estimate of the comparatvie brightness, that would

correspond to a distance from us 9,000,000 times greater than that of the sun. This would correspond with a parallax of one-forty-fifth of a second and a distance which would require nearly 150 years for light to travel. In miles, the distance would be 830 millions of millions of miles. The distance of the two stars optically would be one-thirtieth of a second, far beyond the reach of Burnham with any telescope he will ever live to look through.

We have therefore the elements of the orbit thus determined, the distance apart of the two stars, the period and the masses. These elements are only approximate, however, for we have assumed the plane of the orbit to pass nearly through the earth. If the plane were at right angles with the line joining the star and the earth, there would be no relative motion of approach or recession, and no separation of the lines. Another star of equal brightness might be composed of two stars of the same size revolving in precisely the same manner, excepting that the plane of the orbit should be at right angles to us, and we could never by this method discover its duplicity.

Suppose that the orbit is between these two positions. Suppose that it is at an angle of sixty degrees with the line of sight. In that case the actual relative motion would be twice as great as the apparent relative motion. The actual distance of the two bodies from each other would be twice as great as our calculations would show; and the combined masses would be four times as great to preserve circular motion at this increased distance.

We have assumed circular motion. It would require a very considerable variation from a circular orbit to make itself apparent, or to materially affect our results. With an orbit as excentric as some of the asteroids, the motion would be a little faster at a given distance with a given mass; so that a little less mass would be required than for a circular orbit. But the difference would be very much less than the uncertainty in the determination of the exact separation of the lines, and very much less than the uncertainty in the position of the orbit. Indeed it is manifest that if the plane of the orbit were very nearly at right angles with the line of sight and yet the relative apparent motion sufficient to produce an appreciable separation of the lines, our com-

putations by the above described method would be widely in error. On the other hand there might be a considerable deviation of the plane from coincidence with the line of sight, without materially affecting the computations; and the chances are strongly in favor of the supposition that the main element of uncertainty is the exact determination of the amount of the separation of the lines. If such discoveries should be many times repeated, including many fainter stars, it would then become probable that among them all, there would be one or more to which our mode of computation would not accurately apply. The question would then arise for science to devise some new test to meet this emergency. And difficult as is the problem, we may reasonably expect success.

AN EXAMINATION OF THE PLACE OF TYCHO BRAHE'S STAR.

S. W. BURNHAM.

For The Messenger.

Having some observations to make in Cassiopeiæ, near the observed place of the celebrated temporary star of 1572, known as Tycho Brahe's star, I took occasion to examine, with the 36-inch telescope, the region about the point given by D'Arrest as the most probable place of this star. Of course it was not so much in the hope of finding anything new which could be connected with what is known in the newspapers as the "Star of Bethlehem," as to see whether any new discovery of interest could be made with the large telescope in that vicinity. The particular point assigned by D'Arrest for this star is not closely marked by any stars bright enough to be included in Argelander's Catalogue, but there are several of about the ninth magnitude within a radius of 15′ or 20′. D'Arrest has given a diagram of all the faint stars down to 16 magnitude covered by a space of $4\frac{1}{2}^m$ of right ascension by 50′ of declination. I did not undertake to ascertain how many more could be seen with this instrument, but presumably the number would be largely increased. None of these faint stars presented any peculiar appearance worth noting. The brighter adjacent stars were then examined, and one of the nearest of the Argelander

stars, D. M. (63°) 48, was found to be a close double. The mean of three nights' measures gives

$P = 31°.9 \quad D = 0''.52 \quad$ Mags. 9.2, 9.3 1890.74

This is 2^m following and 18′ north of the assigned place of the Tycho Brahe star. It would probably be very difficult with a moderate aperture, if not beyond its reach altogether. The place of this star for 1880 is:

R. A. $0^h\ 19^m\ 57^s.7$
Decl. 63° 46′ 2″

About 8′ north and a little following is a 12″ pair of 9–10 magnitude stars.

Another star differing but little in declination from D'Arrest's place, but further following in R. A. was found with the 12-inch to be an unequal double. The measures with the 36-inch on three nights give

$P = 90°.2 \quad D = 1''.66 \quad$ Mags. 8.4, 11.3 1890.74

This is D. M. (63°) 52, and is rated 8 mag. by Argelander. In the future these stars may prove to be of some interest.

OUR KNOWLEDGE OF MARS.

JOHN RITCHIE, JR

The planet Mars, during the few years past, has received considerable attention from journalists and writers, who have discussed it with that tendency towards the sensational which is so characteristic of these days. A plain statement, therefore, of our present knowledge, drawn, as much as may be, from the writings of the observers themselves, will not be out of place. While it is to be regretted that absolute conclusions cannot be deduced from our known facts, this failure is of no great moment, for it is better to know a little and know it well, than to know a great deal, and have it not true.

The planet Mars is our neighbor in space, and presents such analogies to our own conditions as to be of great interest to us. In size it is inferior to the earth; in climate not widely different; and it is by no means impossible that

life on Mars may have reached the perfection which it enjoys here. Its time of revolution about the sun is two years, and its distance as compared with that of the earth about as three to two. At conjunction its disk measures about four seconds of arc, while at opposition it is sometimes as large as thirty seconds, hence it is more easily observed at these times.

White spots were possibly indicated on drawings of Mars made in the seventeenth century, and early in the eighteenth they were positively shown. Two of these spots have remained with constancy, and have been termed the snowy poles, which are generally considered analogous to our own poles. Since the map of Mädler, in 1830, drawings of Mars have been made, until many hundreds are in existence, and if due dependence could be placed in the accuracy of the representations, much information might be deduced.

Observers have noted changes in the physical aspect of the planet. Some of these—the slow variation of the polar caps, for instance—are relatively easy to follow. Others are even more rapid, being accomplished in a few days, while other effects are different from one day to another. Among the last class is the so-called "doubling" of the canals. Finally, other changes are found to coincide in time with the period of revolution. Many difficulties lie in the way of an accurate and complete study of these changes. Observations are limited to certain hours of the day, and also to that period of four months when Mars is near opposition. The oppositions occur in different parts of its orbit and under varying inclinations of its axis, so that at least sixteen years is necessary for the complete inspection of the planet. In addition, there are our conditions of atmosphere, and finally the difficulty in comparing the observations made by different men with different telescopes on account of instrumental and personal peculiarities.

Upon certain differences in color rests the notation "continent," "sea," "canal," "island," etc. This notation must be regarded only as a matter of convenience, and positively does not imply anything with reference to the physical condition of the surface. Some regions, usually of small area, are sometimes seas, sometimes continents. In the light of this statement, it is interesting to note M. Flammarion's

position in a paper in the *Comptes Rendus* in 1873. This summed up the known facts at that date. Briefly his statements are:—the polar regions are covered with snow, there are clouds and atmospheric currents, the atmosphere being more saturated in Winter than in Summer, the surface is quite evenly divided into land and sea, the meteorology is similar to ours, water exists in the same state physically and chemically, the continents are covered with forests of a reddish hue, and the conditions for life are little different from those of the earth. With the sanguineness and ardor of his nation he made at this time a series of claims, which, seventeen years later, with whatever has been added to scientific knowledge in the interim, cannot be considered as at all well proven in many respects.

The canals are an interesting feature of the surface of Mars. Much of the information concerning them is from the Italian observer Schiaparelli, a good, careful, accurate and reliable astronomer. These canals, according to him, cover with a network all of the continental region. They form usually an arc of a great circle, some of great length, as much as ninety degrees, and vary greatly among themselves in breadth. Their visibility, breadth and form vary from one opposition to another, and even during the course of a week. These changes are not simultaneous, but partly local, so that a map must be regarded rather as a topographical index than as a representation of the actual appearance. Every canal ends in a sea or another canal—an important feature of an unknown import. Schiaparelli characterizes the physical circumstances connected with the canals as follows: A canal may be invisible for a longer or shorter time, it may be obscured by the variation of the color of the adjoining surface, the type is dark in color, but sometimes is like a faint gray stripe, and canals vary greatly in width.

During the opposition of 1881-2, Schiaparelli made some discoveries which have excited much discussion. During fifty consecutive nights, sixteen perfect and fourteen exceedingly fine (in Italy), these observations were made. The chart which accompanies his paper to the Society of Italian Spectroscopists is suggestive of a double printed photograph. His discovery, as he states it, was that a canal

would, in a few days, sometimes a few hours, appear as if composed of two parallel stripes, one of which, usually, occupied the true space of the canal. The relation of the stripes to the place between them varied in different canals, the color of both stripes was the same, and all irregularities, if present in the single canal, disappeared on "doubling." Sometimes at the intersection of two canals the duplication would stop, and the same canal would be both single and double in different parts. Schiaparelli observed these features in wonderful detail and was even able to follow the process of "doubling" in one or two instances. In 1886, Perrotin of Nice consideered that his observations strongly confirmed those of Schiaparelli. During the opposition of 1888 Mars was much observed. Perrotin notes that part of the canals seen by him two years before, in the same places and of the same character, some simple, others double. He signalizes some marked changes, the disappearance of a continent, Lybia, (about as large as France), and of a lake, and the appearance of a canal across the north polar cap.

Unfortunately for the observer at Nice, Niesten of the Observatory of Brussels had made drawings of Mars at an interval of six days, during which interval Perrotin took his observation. The continent which he declares *complement disparu* appears on both of the Belgian drawings. Although with French politeness M. Niesten explains how the continent might have suddenly reappeared, the inference is obvious, and as an observer of Mars, confidence in Perrotin has sustained a shock—and unfortunately, since he has been so strong a supporter of Schiaparelli. Niesten goes on to state that he has not been able to see the duplicated canals, although some can be seen single while others resemble the boundary lines of two different tints of the planet's surface.

Coming nearer home, Prof. A. Hall, of Washington, observed Mars carefully with the great refractor of the Naval Observatory at Washington, on eighteen nights in 1888, but failed to see the regular canals of the European observers. Prof. E. S. Holden, of the Lick Observatory, states in the Astronomical Journal that, while the most favorable time for observation had passed before the Lick telescope could be used, still he secured a fair series of results. With regard to the canals, he failed to see any "doubling." Lybia was

frequently drawn here during the period of its disappearance from France.

Various theories to account for the existence of the canals have been suggested. The notion that they can be the work of inhabitants fails on account of the enormous size of these lines, sometimes a thousand miles long and fifty broad. Fitzeau's theory of glacial crevasses demands the existence of forces of such magnitude as to be unreasonable from an earthly standpoint, and no hypothesis has been suggested, which can be to-day accepted as reasonable.

The matter rests here, then, in an unsatisfactory condition with regard to the physical phenomena of Mars. On the one hand, we have skillful and competent astronomers asserting the existence of markings, and furnishing drawings containing the most minute details. On the other hand, equally trustworthy authority, with at least equal optical means, confess their inability to see even the most prominent features of the objects whose existence is in dispute. The weight of judgment among astronomers inclines to skepticism on the subject, but in either event we must wait patiently until further observations shall establish or disprove the truth of the alleged discoveries.—*Boston Commonwealth, Oct. 18, 1890.*

STATIONARY OR LONG-ENDURING METEOR-RADIANTS.

W. H. S. MONCK.

FOR THE MESSENGER.

In my article on Stationary Meteor-Radiants, which appeared in your October number, I find I was inaccurate in describing the fire-ball whose period was computed at 462 days as an Andromede. Though agreeing in date with the Andromede shower and bearing some other points of resemblance it was, I find, referred to a different radiant.

I have also been informed that my assumption that the vessel would carry the balls with it in its motion is erroneous. I only referred to the balls as an illustration of my theory. A better one would probably have been a number of boats or steamers crossing the current. I offered this explanation as far back as the year 1885 (see *The Observa-*

tory for December, 1885 and January, 1886), but stationary radiation was then regarded as an exceptional case whereas I now regard it as the rule if not an invariable law. The explanation however involves difficulties which renders me very doubtful of its validity. My pamphlet (to which you refer in a subsequent note) was only printed for private circulation.

With regard to the supposed cometary showers I may note that though no position very near the Lyrids or Leonid radiants appear in Mr. Denning's list at other times of the year the observations of others go far to supply the deficiency. Moreover the Perseids and Lyrids do not seem to exhibit any periodicity agreeing with that computed for the comet.

It is worthy of remark that, should my theory prove correct, meteor-radiants may be determined by projecting the paths of meteors observed at any time of the year instead of confining our attention to those observed nearly at the same date. A much larger amount of information may thus be derived from observations already collected.

For the convenience of those who may wish to test my statement that when Mr. Denning's Catalogue is arranged in order of R. A. the grouping becomes immediately apparent, I give a list of the radiants for the second quadrant (which I prefer to the first as avoiding the question of shifting radiants) in order of R. A. The numbers are those in Mr. Denning's Catalogue.

R. A. 90° to 180°; Nos. 712, 698, 707, 659, 722, 675, 723, 647, 699, 718, 703, 915, 713, 660, 302, 743, 734, 607, 905, 608, 589, 871, 700, 787, 507, 834, 609, 539, 751, 590, 641, 864, 648, 770, 835, 389, 860, 661, 36, 853, 674, 704, 875, 719, 591, 714, 677, 916, 478, 762, 876, 592, 614, 595, 727, 865, 880, 843, 678, 752, 854, 560, 797, 811, 540, 662, 907, 861, 601, 610, 877, 663, 593, 3, 686, 687, 705, 911, 763, 786, 720, 728, 679, 771, 764, 594, 688, 894, 899, 18, 541, 689, 31, 803, 849, 680, 756, 690, 739, 908, 681, 642, 772, 615, 891, 291, 664, 460, 844, 691, 917, 10, 812, 804, 862, 114, 878, 855, 692, 780, 765, 866, 900, 13, 292, 814, 773, 774, 781, 775, 801, 782, 788, 665, 879, 693, 789, 815, 542, 805, 790, 872, 24, 122, 482, 60, 873, 850, 918, 175, 69, 895, 881, 796, 4, 40, 673, 912, 806, 824, 882, 48, 61, 46, 909, 682, 825, 19.

DUBLIN, Oct. 30, 1890.

BRITISH ASTRONOMICAL ASSOCIATION.

The first general meeting of this Association was held on Friday, the 24th of October, in the Hall of the Society of Arts Adelphi. The chair was taken by W. H. Mead, Esq., temporary treasurer; Mr. E. W. Maunder, temporary secretary, read the report of the provisional committee, giving an account of the formation of the Association up to the date of the election of the Council. The report having been unanimously adopted, the senior scrutinist, Edwin Durkin, Esq., F. R. S., read the certificate of the election of the Council and Mr W. H. Wesley read the certificate of the election of officers by the Council. The meeting having unanimously confirmed these elections and also the appointments of the directors of sections Captain W. Noble, F. R. A. S., took the chair as president of the Association and the meeting proceeded to the discussion of the rules. After careful consideration, and in order to avoid any posible confusion or misconception between the names of this Society and the Royal Astronomical Society, especially abroad, it was decided to alter the name by substituting the word Association for Society. The hour of five o'clock was fixed upon as the time for the meetings of the Association in the hope that it might be found convenient both by town and country members. The month of June was selected for the annual meeting. Several alterations were made in the draft rules. The meeting closed with votes of thanks to the chairman and the provisional committee.

The first *public* suggestion for the formation of this Society was made by Mr. Monck in a letter to the "English Mechanic" of July 18th of this year, and shortly afterwards Mr. E. W. Maunder undertook the task of ascertaining the views of a number of gentlemen interested in Astronomical research on the subject, his letters in every case containing a suggested programme. The responses were in almost every instance so satisfactory, and the offers of co-operation so numerous that a printed circular embodying the suggested programme, and bearing the names of those gentlemen who had promised assistance was sent out. The issue of this circular and notices in the public press brought an immediate accession of numbers and further offers of support. A

second circular, containing a somewhat fuller programme, and including the additional names of those ladies and gentlemen who had in the meantime consented to serve on a provisional committee, was issued a few days later.

The accessions to the Society proceeded so rapidly that toward the end of August the provisional committee after careful consideration, decided upon the following scheme:

1. That the Council of the Society should consist of,

(*a*) Eight officers, viz: A president, four vice-presidents, treasurer, secretary and editor,

(*b*) Fourteen ordinary members.

(*c*) Eight (or more) directors of sections who should be *ex-officio* members.

2. That for the election of the first Council a list of thirty names selected by the committee from a full list of members should be submitted to a ballot of the Society and that the twenty-two highest names should constitute, together with the directors of sections, the first Conncil.

3. That this Council should elect the officers of the Society, prepare a draft of rules, and call a general meeting at the earliest convenient date.

4. That the general meeting should confirm or otherwise the election of officers and directors of sections and discuss and pass a code of rules.

These resolutions were carried into effect without any delay. Ballot reports were duly issued to every member of the Society, and on Oct. 1st two scrutineers appointed for the purpose, by the committee, Edwin Durkin Esq., F. R. S., and E. E. Baly, Esq., deputy chief cashier of the Bank of England, met and counted the votes. The first meeting of the Council was held on Oct. 8th, and the officers of the Society were elected and a code of rules drafted, and Friday the 24th of October, was fixed upon as the date for the general meeting. A notification to that effect together with a printed copy of the draft rules and a circular containing the names of the members of the Council, the officers of the Society and the directors of sections, was forwarded to each member.

THOMAS F. MAUNDER, Asst. Secretary.
26 Martin's Lane, Cannon Street, London, E. C.

THE CORRECTION OF OBSERVATION DATA BY THE METHOD OF LEAST SQUARES.*

HERBERT WHITAKER

In observations there are two possible sources of error: first, accidental errors, which are of such a nature that in the long run they are as apt to be positive as negative, thus tending to eliminate each other; and, second, systematic errors which are of the same sign and tend to cumulate. An error in reading a scale is an instance of an accidental error, but an unknown error in the length of a scale used is an instance of a systematic error: for in the long run an observer would be as apt to read a scale too long as too short, but observations with an incorrect instrument of measurement evidently do not tend to eliminate each other, being, on the contrary, cumulative.

Suppose that a mile were measured by a 100-foot chain making 53 measurements necessary, and that the chain pins were misplaced two inches at each measurement and suppose that the chain itself were one inch out. Now it is shown by the theory of probabilities that in accidental errors, the square root of the whole number of errors are probably uneliminated in the total; in this case the total accidental errors due to the setting of the pins would be the square root of 53 times 2 inches or 14 inches; while the total systematic error due to the incorrect length of the chain would be 53 inches, nearly four times as much as that due to accidental error, although each of these last errors was only one-half of the first.

Systematic errors furnish no trace of their presence, even in repeated observations, since they affect all of the observations alike; and the presence of this class of errors in a series of observations constitutes the greatest obstacle to the accurate determination of the values of any quantities sought. They can however be transformed into accidental errors by varying the method of observation. Thus by employing a number of different standards of measurement in the same series of observations the cumulative errors due to an erroneous standard, would be transformed to eliminative errors, since different standards are as likely to be too short as too long.

* A paper read before the Camden Astronomical Society.

In the method of obtaining most probable values of unknowns from observation data, it is of necessity assumed that systematic errors have been eliminated.

Suppose it were desired to determine a general expression for the accelerative force at the surface of the earth, due to the earth's attraction. From theoretical considerations, the form of the expression is known to be

$$g = x - y \cos 2\lambda$$

in which x and y are constants to be determined and λ is the latitude.

Suppose observations to have been made at six different places and the values of g (π^2 times the length of the second's pendulum), and of λ so obtained were substituted in the above equation, giving six equations with two unknown quantities. Such equations are called observation equations, evidently any two of them being sufficient to determine the constants x and y; but if the values obtained from any two of them were substituted in the other four of the observation equations, there will generally be a slight difference in the values of the right and left hand members of each of these equations. These differences have been called residuals and by a course of analysis based upon the theory of probabilities, it has been shown that the most probable values of the unknown quantities are those which make the sum of the squares of their residuals a minimum, and hence the name of Least Squares.

To form the equations filling this condition, everything in each of the observation equations is transposed to one side and, instead of zero, the other side is called e', e'' e''', etc.; thus $g - x + y \cos 2\lambda = e'$. Each equation is now squared and the sum is taken, giving the value which is to be a minimum.

To determine this minimum, the first differential coefficient of the sum of the squares of the equations must be equated to zero and so taking the first differential coefficient of this expression with reference to one of the unknowns, say x, equating to zero and comparing with the observation equations and it is seen that the equation involving the condition that the sum of the squares of the errors shall be a minimum is obtained by multiplying each of the observation equations by the coefficient of x in that equation and taking the sum of

all the equations thus formed. The same process is gone through with for each of the other unknowns; thus for y, multiply each of the observation equations by the coefficients of y in that equation and take the sum of all the equations thus formed. Having operated in this manner for each of the unknowns, there results as many equations as there are unknowns and the roots of these equations furnish the values sought.

If the purpose of the observations were the measurements of a single quantity, such as a length, the form of the observation equation would be $l = x$, and to find the most probable value of x, the sum of the measurements is taken and divided by the number of the measurements since the coefficient of x was one in each equation. But this is the process of finding the arithmetic mean and it thus appears that the practice of taking the average of all the measurements of a quantity as the most probable value of that quantity is a particular case under the method of Least Squares. If the observer feels that on account of circumstances attending the observations, the accuracy of some of them can be depended upon more than others, the equations are weighted as it is called. Thus, if the accuracy of three observations are considered to be in the ratios of 1, 2 and 3, the second observation equation would be repeated twice and the third one three times before being operated on by the usual method.

When a formula is sought, if the causes which are operating are known, the form of the observation equations can usually be determined by mathematical analysis; in other cases such empirical formula as

$$y = a + bx + cx^2 + dx^3 + \text{etc.},$$

and $$y = a + b \sin \frac{x}{n} + c \sin \frac{2x}{n} + d \sin \frac{3x}{n} + \text{etc.}$$

$$+ b_1 \cos \frac{x}{n} + c_1 \cos \frac{2x}{n} + d_1 \cos \frac{3x}{n} + \text{etc.}$$

could be used.

Camden Astronomical Society. At the regular meetings of the Camden Astronomical Society held during the present year, the following papers have been read: On the probable age of the World, by R. M. Luther, D. D.; A review of Borrelli's "De Vero Telescopii Inventore," by H. H. Furnes, Jr.; On light, by T. Worcester Worrell; On the Date of the Settlement of Ancient Egypt from an Astronomical point of view, by Edward F. Moody; On the Method of Least Squares, by Herbert Whitaker.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be visible to the eye on a few evenings in the latter part of December, when he will set in the south west about an hour and a half after sunset. He will be at greatest elongation, east from the sun 19° 38′, Dec. 27; at the ascending node of his orbit Jan. 2; at perihelion Jan. 7, and at inferior conjunction with the sun Jan. 13 at 11^h 31^m A. M. central time.

Venus will be at inferior conjunction Dec. 3 at 10:24 P. M. central time. At that time Venus will be only 36′ south of the sun's center or 20′ from the south limb of the sun. Rev. S. J. Johnson (*Observatory, Nov. 1890, p. 357*) calls attention to the possibility of seeing the thread of light, due to the planet's atmosphere, encircling Venus at the time of this conjunction. In Dec., 1866, when Venus was very near her node at inferior conjunction, and passed unusually near the line from the earth to the sun, Professor Lyman, of Yale College Observatory, was able to see the fine thread of light completely encircling the planet. For southern observers the position of Venus at this conjunction will be very favorable for the observation of this phenomena. In the northern hemisphere the low altitude of the planet is unfavorable, but it may be possible for observers to catch glimpses of the planet on the afternoon of Dec. 3, or the morning of Dec. 4.

The article on Venus by G. V. Schiaparelli is concluded in the November number of *L'Astronomie*. He reaches the conclusion that the rotation of Venus is very slow, the period being probably 224.7 days, or the same as that of its sidereal revolution about the sun, and about an axis very nearly perpendicular to the plane of its orbit. That is to say, Venus always keeps the same side toward the sun, just as the moon does to the earth, and as Mercury also does to the sun.

Mars is moving rapidly eastward through Aquarius. The change in relative position of the two bright planets, Mars and Jupiter, has been very noticeable during the past month. The distance of Mars from the earth is now about one and one-half times the distance of earth from sun, so that its disk is very small and but little detail can be seen upon its surface, under ordinary circumstances. An interesting article by Dr. Terby on the observations of Mars during this opposition is given in *L'Astronomie* for November. The opposition has been an unfavorable one for northern observers, on account of the low altitude of the planet, but a large number of Schiaparelli's "canals" have been identified and several have been seen doubled. Observations by Messrs. A. Stanley Williams, Schiaparelli, Terby and W. H. Pickering are cited.

We have recently had the pleasure of examining two fine drawings of Mars, made during the past summer by Mr. J. E. Keeler with the great Lick telescope, which show several of the canals. But the most noticeable features of one of these drawings were two white projections beyond the terminator of the planet in the northern hemisphere. These seem to indicate the presence of clouds at a considerable elevation in the atmosphere

of Mars. They were so obvious as to be noticed by a visitor who, looking through the great telescope on the regular visitor's night, called attention to their existence.

Jupiter is getting too near the sun to be well observed, but may be seen for about three hours after sunset near the southwest horizon. We have been permitted to examine four very excellent drawings of Jupiter made by Mr. Keeler with the Lick telescope, three of them during the present year. These show a wonderful amount of detail upon the face of the planet. An interesting fact, about which there has been considerable dispute, appears to be shown by these drawings; that is, that the dark markings, which have a shorter period of rotation in the same latitude with the great spot, seem to flow around the latter as they pass by it, just as the water of a stream flows around an island. Mr. Keeler says that it is undoubtedly true that dark markings, on coming up to the red spot, are forced to one side and crowded together, so as to have a denser appearance, and that their latitude is permanently changed. On the other hand, *L'Astronomie* gives an account of an observation made by M. Stuyvaert at Bruxelles August 25, 1890, when the red spot was found to be partially covered by the grey temperate band of the southern hemisphere. This observation was confirmed by Messrs. Niesten and Stuyvaert on August 30, when the same appearance was again noticed. This would indicate that the red spot is at lower level than the dark markings.

Saturn may be observed after midnight. He may be easily found toward the east in the lower part of the constellation Leo, being brighter than any of the stars in that vicinity. Saturn will be at quadrature December 8, and stationary in right ascension December 28. Mr. Marth's ephemerides of the satellites of Saturn for November and December, 1890, have just come to hand in *Monthly Notices*, Vol. L, No. 9. Those for 1891 will be given in the next number of the *Monthly Notices*. We notice that Titan will be in transit across the disk of the planet December 4, inferior conjunction occurring at 9 3^h P. M. central time. Titan will be occulted December 13, superior conjunction 7″ south of Saturn's center, at 3 6^h A. M. There will be a transit of Titan again December 20 at 8.4^h P. M.

Uranus may be seen in the morning after 3^h A. M. He is near the foot of Virgo about 10° directly east from Spica and 2° south west of the third magnitude star κ Virginis.

Neptune may be seen all night. In the early evening he is toward the east. The groups of the Pleiades and the Hyades with the bright red star Aldebaran are easily recognized. Neptune is about one third of the way on a straight line from Aldebaran to the Pleiades. A telescope of considerable power will be needed in order to distinguish this planet by means of its disk.

MERCURY.

Date. 1890	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Dec. 25	19 42.0	− 23 04	9 00 A. M.	1 25 0 P. M.	5 50 P. M.
Jan. 4........	20 10.2	− 19 34	8 32 "	1 13.9 "	5 56 "
14........	19 32.8	− 18 28	7 10 "	11 57.2 A. M.	4 44 "

VENUS.

Date. 1890	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Dec. 25........	16 12.7	− 17 14	5 03 A. M.	9 56.2 A. M.	2 49 P. M.
Jan. 4........	16 22.6	− 16 50	4 32 "	9 26.8 "	2 21 "
14........	16 44.6	− 17 27	4 18 "	9 09.5 "	2 01 "

MARS.

Date. 1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Dec. 25	22 34.9	− 9 56	10 54 A. M.	4 17.5 P. M.	9 41 P. M.
Jan. 4	23 02.7	− 6 57	10 30 "	4 05.8 "	9 42 "
14	23 30.0	− 3 52	10 06 "	3 53.7 "	9 42 "

JUPITER.

Date.	R. A.	Decl.	Rises.	Transits.	Sets.
Dec. 25	21 02.6	− 17 39	9 59 A. M.	2 49.3 P. M.	7 40 P. M.
Jan. 4	21 12.1	− 16 58	9 22 "	2 15.5 "	7 10 "
14	21 21.1	− 16 17	8 48 "	1 45.2 "	6 42 "

SATURN.

Date.	R. A.	Decl.	Rises.	Transits.	Sets.
Dec. 25	11 15.9	+ 6 51	10 26 P. M.	4 56.3 A. M.	11 27 A. M.
Jan. 4	11 15.7	+ 6 55	9 46 "	4 16.8 "	10 48 "
14	11 14.9	+ 7 03	9 05 "	3 36.6 "	10 08 "

URANUS.

Date.	R. A.	Decl.	Rises.	Transits.	Sets.
Dec. 25	13 54.8	− 11 12	2 23 A. M.	7 38.8 A. M.	12 55 P. M.
Jan. 4	13 56.0	− 11 18	1 43 "	7 00.7 "	12 19 "
14	13 57.0	− 11 23	1 05 "	6 22.4 "	11 40 A. M.

NEPTUNE.

Date.	R. A.	Decl.	Rises.	Transits.	Sets.
Dec. 25	4 12.0	+ 19 27	2 29 P. M.	9 53.5 P. M.	5 18 A. M.
Jan. 4	4 11.0	+ 19 25	1 49 "	9 13.3 "	4 38 "
14	4 10.3	+ 19 23	1 08 "	8 33.2 "	3 57 "

THE SUN.

Date.	R. A.	Decl.	Rises.	Transits.	Sets.
Dec. 20	17 55.1	− 23 27	7 34 A. M.	11 58.0 A. M.	4 22 P. M.
25	18 17.3	− 23 24	7 36 "	12 00.5 P. M.	4 25 "
30	18 39.4	− 23 09	7 37 "	12 02.9 "	4 29 "
Jan. 4	19 01.5	− 22 42	7 37 "	12 05.2 "	4 33 "
9	19 23.4	− 22 04	7 36 "	12 07.4 "	4 39 "
14	19 45.0	− 21 16	7 34 "	12 09.4 "	4 45 "

THE MOON.

Date.	R. A.	Decl.	Rises.	Transits.	Sets.
Dec. 20	1 47.9	+ 7 01	1 15 P. M.	7 50.1 P. M.	2 38 A. M.
25	6 20.3	+ 25 10	3 55 "	12 02.1 A. M.	8 11 "
30	10 42.5	+ 13 44	8 50 "	4 03.3 "	11 15 "
Jan. 5	14 32.7	− 11 52	2 05 A. M.	7 33.6 "	12 56 P. M.
10	19 37.6	− 24 47	7 54 "	12 18.0 P. M.	4 45 "
15	0 40.1	− 0 46	10 56 "	5 00.2 "	11 17 "

Phases and Aspects of the Moon.

			Central Time. d	h	m
First Quarter	1890	Dec.	18	2	36 P. M.
Full Moon	"	"	25	11	57 "
Last Quarter	1891	Jan.	3	4	12 A. M.
New Moon	"	"	10	9	25 "
Apogee	1890	Dec.	30	8	00 P. M.
Perigee	1891	Jan.	11	7	48 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N.P't. °	Duration. h m
Dec. 15	33 Capricorni	5.5	6 36	95	7 31	215	0 55
18	B.A.C. 17	6	6 50	99	7 43	188	0 53
19	26 Ceti	6	8 56	69	10 07	223	1 11
19	29 Ceti	6.5	11 36	70	12 36	235	1 00
21	38 Arietis	5.	9 01	82	10 16	215	1 15
Jan. 7	39 Ophiuchi†	5.5	17 10	167	17 40	227	0 30

† Multiple Star.

Saturn's Satellites.

[Central Time; E = eastern elongation; I = inferior conjunction; W = western elongation; S = superior conjunction.]

JAPETUS.

Dec. 28	E.	Jan. 16 11.2 A. M.	I.

TITAN.

Dec. 17 5.4 A. M. E.	Dec. 29 4.7 A. M. S.	Jan. 9 8.9 P. M. W.
21 5.1 " I.	Jan. 1 11.6 P. M. E.	14 12.5 A. M. S.
25 4.9 " W.	5 6.9 " I.	

RHEA.

Dec. 17 11.6 P. M. E.	Dec. 31 12.8 P. M. E.	Jan. 14 1.6 A. M. E.
22 12.0 M. E.	Jan. 5 12.9 A. M. E.	
27 12.5 A. M. E.	9 1.3 P. M. E.	

DIONE.

Dec. 15 8.3 A. M. E.	Dec. 26 7.2 A. M. E.	Jan. 6 5.8 A. M. E.
18 2.0 A. M. E.	29 12.8 A. M. E.	8 11.5 P. M. E.
20 7.7 P. M. E.	31 6.4 P. M. E.	11 5.1 P. M. E.
23 1.4 P. M. E.	Jan. 31 12.1 P. M. E.	14 10.8 A. M. E.

TETHYS.

Dec. 16 12.3 A. M. E.	Dec. 27 8.2 A. M. E.	Jan. 7 3.6 P. M. E.
17 9.7 P. M. E.	29 5.5 A. M. E.	9 12.9 P. M. E.
19 7.0 P. M. E.	31 2.8 A. M. E.	11 10.2 A. M. E.
21 4.3 P. M. E.	Jan. 1 11.8 P. M. E.	13 7.6 A. M. E.
23 1.6 P. M. E.	3 9.0 P. M. E.	
25 10.9 A. M. E.	5 6.3 P. M. E.	

Phenomena of Jupiter's Satellites.

d.	Central Time. h. m.				d.	Central Time. h. m.			
Dec. 17...	4 33	P. M.	IV.	Ec. Dis.	Dec. 26...	5 16	P. M.	III.	Sh. Eg.
17	5 05	"	II.	Oc. Dis.	26	5 38	"	II.	Tr. Eg.
19	4 54	"	II.	Sh. Eg.	27	4 35	"	I.	Tr. Eg.
26	4 22	"	II.	Sh. In.	27	5 24	"	I.	Sh. Eg.
26	5 01	"	I.	Oc. Dis.					

Minima of Variable Stars of the Algol Type.

Star's Name.	R.A. h m s	Decl. ° ′	Central Times of Minima.
U Cephei	0 52 32	+81 17	Dec. 20, 4 A.M.; 25, 3 A.M.; 30, 3 A.M.
			Jan. 4, 3 A.M.; 9, 2 A.M.; 14, 2 A.M.
Algol	3 01 01	+40 32	Dec. 28, 2 A.M.; 30, 10 P.M.; Jan. 2, 7 P.M.
R Canis Maj.	7 14 30	−16 11	Dec. 16, midn.; 18, 3 A.M.; 19, 6 A.M.
			Dec. 26, 2 A.M.; 27, 5 A.M.; Jan. 3, 1 A.M.
			Jan. 4, 4 A.M.; 10, midn.; 12, 3 A.M.
S Cancri	8 37 39	+19 26	Dec. 25, 11 P.M.; Jan. 12, 10 P.M.
δ Libræ	14 55 06	− 8 05	Dec. 21, 5 A.M.; 28, 5 A.M.
			Jan. 4, 4 A.M.; 11, 4 A.M.
U Coronæ	15 13 43	+32 03	Dec. 23, 6 A.M.; 30, 3 A.M.

A Central Eclipse of the Sun will occur on Dec. 11 beginning at $6^h\ 22^m$, and ending at $11^h\ 43^m$ central time. It will be invisible in the United States, and only visible in Australia and the South Polar Seas.

COMET NOTES.

Ephemeris of Comet 1890 II. (*Brooks March 19*). As Bidschoff's elements given in *A. N.*, Vol. 124., p. 301, still represent the observations sufficiently well, being obtained from long intervals, I have computed the following ephemeris from them for December.

The constancy of the light at the present time is worthy of note. If we call the light on December 1 unity, the light on Dec. 31 will be 1.01, and on February 1, 1891 0.98; while on November 1, it was 1.08. As the comet is also becoming still more favorably situated for observation, with respect to the sun, it probably will be visible for some time to come:

Gr. M. T.	App. R. A.	App. Dec.	Log. r.	Log. Δ.
	h m s	° ′		
Dec. 1.5	13 9 49	+ 26 10	0.4620	0.4921
2.5	9 34	26 13		
3.5	9 18	26 16		
4.5	9 1	26 20		
5.5	8 42	26 23	0.4670	0.4875
6.5	8 22	26 27		
7.5	8 1	26 31		
8.5	7 38	26 36		
9.5	7 15	26 40	0.4720	0.4827
10.5	6 50	26 45		
11.5	6 24	26 50		
12.5	5 56	26 55		
13.5	5 27	27 0	0.4769	0.4775
14.5	4 57	27 5		
15.5	4 24	27 11		
16.5	3 52	27 17		
17.5	3 15	27 23	0.4818	0 4721
18.5	2 38	27 29		
19.5	1 59	27 36		
20.5	1 19	27 42		
21.5	13 0 37	27 49	0.4866	0.4666
22.5	12 59 53	27 56		
23.5	59 8	28 4		
24.5	58 20	28 11		
25.5	57 31	28 18	0.4914	0.4610
26.5	56 40	28 26		
27.5	55 47	28 34		
28.5	54 52	28 42		
29.5	53 55	28 51	0.4962	0.4554
30.5	52 56	28 59		
Dec. 31.5	12 51 54	29 8		
Feb. 1.5	11 59 26	+ 34 19	0.5353	0.4225

O. C. WENDELL.

Harvard College Observatory, Oct. 11, 1890.

D'Arrest's Comet. D'Arrest's Comet has been observed by me with the 10½-inch refractor, which now shows it well, although I have searched for the comet several times during the summer and autumn previous to its detection by Barnard. This indicates that the comet has been growing brighter of late, although the theoretical brilliancy should have been greatest about the first of September. On November 5th I found the comet to be in R. A. $21^h\ 13^m\ 20^s$, —27° 31′. On Nov. 6 in R. A. $21^h\ 17^m$ 20, — 27°

28′. These places agree well with the sweeping Ephemeris published in the *A. N.* The comet is rather faint, pretty large, and with very slight central condensation. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y., Nov. 8th, 1890.

D'Arrest's Comet on Nov. 4 was easily seen with our 8-inch refractor. It was quite large and diffuse, having no distinct central condensation which might be taken as the point of measurement. The following ephemeris by M. Leveau indicates that it may be visible for some time yet:

Ephemeris of d'Arrest's Comet.

Paris Noon	R. A.	Decl.	Brightness.
Dec. 2	$22^h 44.9^m$	− 22° 43′	0.22
6	22 57.0	21 44	
10	23 08.7	20 42	0.18
14	23 19.9	19 39	
18	23 30.8	18 35	0.15
22	23 41.4	17 31	
26	23 51.7	− 16 26	0.12

Astr. Nach. 2959.

Comet e 1890—(Zona)—A telegram was received November 17, announcing the discovery of a bright comet by Zona at Palermo, Nov. 15 .3963 Gr. M. T. in right ascension $5^h\ 35^m\ 53.9^s$ and declination north 33° 23′ 00″. Its daily motion is westward in right ascension $4^m\ 48^s$, in declination north 17′.

Elements and Ephemeris of Comet e 1890. The following elements and ephemeris of Comet *e* 1860 were computed by W. W. Campbell, Observatory at Ann Arbor, Michigan, based on observations of Nov. 15, 18 and 19.

$$T = \text{July } 20.17$$
$$\omega = 317^\circ\ 35'$$
$$\Omega = 84\ \ 25$$
$$i = 153\ \ 02$$
$$q = 1.8229$$

Ephemeris.

	Gr. M. T.	R. A.	Decl.	L.
1890.	Nov. 21	$5^h\ 1^m.1$	34° 38′	0.97
	25	4 37 .2	35 2	
	29	4 14 .5	35 9	
	Dec. 3	3 52 .5	34 56	0.81

The comet discovered by Spitaler Nov. 16.643 in right ascension $5^h\ 27^m\ 16^s$, and in declination 33° 38′, is reported not found by other observers. It is undoubtedly Zona's Comet which was seen at Northfield on the evenings of Nov. 17 and 18. It was faint.

Comet f 1890—(Spitaler).—A telegram was received November 18, announcing the discovery of a faint comet by Spitaler, at Vienna, Nov. 16.6435 in right ascension $5^h\ 27^m\ 16.9^s$ and declination north 33°37′16″, Had it not been for the words, "unhideth not Zona," in the telegram, we should at once have pronounced this an observation of Zona's comet. The word *unhideth* is not found in the code.

One of these comets was observed at Northfield on the night of November 17, but the comparison star was so faint that we have been unable to identify it with any in the catalogues. The comet was very faint and difficult to observe. It was not more than 1′ in diameter, with a slight central condensation. It was seen again on the 18th, but was too faint to observe in the moonlight.

Solar Prominences for October.

DATE.	POSITION ANGLE.
1	239, 300, 346.
4	86, 120, 162, 249, 268, 275, 320.
5	85, 94, 251, 265, 274, 315, 341, 348.
8	75, 130, 264, 314, 348.
9	29, 254, 344.
10	141, 156, 165, 246, 345.
11	64, 132, 135, 140, 183.
12	64.
17	76, 83, 99, 244, 246, 300, 340.
18	66, 99, 247, 274, 325, 340.
19	66, 121, 162.
21	66, 130, 155, 170, 249.
22	66, 276, 305.
25	70, 252, 263.
26	70. 88, 252, 340.
28	68, 260.
30	65, 80, 293.
31	277.

Number of Observations, 18. Number of Prominences, 74. Mean Number of Prominences, 4.11. Highest Prominence on the 17th at P. 99. Height 96″.

Camden Observatory November 1st, 1890.

Smith Observatory Observations. The following solar observations were made with telescopes unless otherwise stated. They were taken by Charles E. Peet:

1890.	90° Mer M T	Groups.	Spots.	Faculæ.	Seeing.	Remarks.
Oct. 16	12:55 p m	0	0	0	Fair *	Gran difficult.
17	3.30 p m	0	0	0	Good.	Gran. good.
19	3 15 p m	1	8	1	Poor	Group too near South east limb to count the spots accurately
20	1·00 p m	1	8	2	Bad.	
23	12 45 p m	2	24	0	Poor.	
31	9·30 a m	1	1	3	Fair.	Spot near W. limb with fac. region about.
Nov 4	2·20 p m	0	0	0	Fair	
11	9 45 a m	1	6	2	Fair.	Gran. fine and distinct.
12	1:30 p m	1	2	0	Good.	Gran good.

* Projection on 20 cm. circle.

Chas. A. Bacon.

Smith Observatory, Beloit College, Nov. 15, 1890.

U. S. Naval Observatory Report for the year ending June 30, 1890, has just come to hand.

Carleton College Sunspot Observations. **(Continued from page 418.)**

[illegible]	Central Time.	Groups.	Spots.	Faculæ.	Observers.	Remarks.
Oct. 23	12:20	2	30	1 gr	C. R. W.	One large spot with finely developed umbra and penumbra—this spot is divided into three parts by light masses and streaks—27 spots in larger group.
27		1	1		"	
Nov. 3	3:10	0	0	0	"	
4	12:35	0	0	0	"	
10	12:20	1	7	1 gr	H. C. W.	One large spot
12	11.00	1	7	0	"	
13	12:35	1	4	0	C. R. W.	
14	12:05	0	0	0	"	
18	9.50	0	0	3 gr	"	
19	12.30	0	0	3 gr	"	
20	12.35	0	0	0	"	

Planetoid (11) Parthenope. The following ephemeris is furnished by Professor Robert Luther of the Observatory at Düsseldorf, in the hope that observations may be made in this country. The magnitude of the Planetoid is 9.7 at opposition which takes place Dec. 29, 1890:

	Berlin Midn. 1890.	R. A. h	m	s	Decl. °	′	″	Log. Δ	Aber'n. Time. m	s
1890	Dec. 13	6	52	7.28	+19	13	15.1	0.223459	13	43
	14		51	11.60		15	20.3	222477		51
	15		50	14.85		17	28.1	221565		49
	16		49	17.11		19	38.4	220723		47
	17		48	18.43		21	51.2	219951		46
	18		47	18.87		24	6.2	219252		44
	19		46	18.31		26	23.3	218626		43
	20		45	17.41		28	42.3	218073		42
	21		44	15.66		31	3.1	217595		41
	22		43	13.31		33	25.6	217192		41
	23		42	10.44		35	49.5	216865		40
	24		41	7.14		38	14.9	216614		39
	25		40	3.46		40	41.4	216440		39
	26		38	59.49		43	9.0	216343		39
	27		37	55.30		45	37.5	216323		39
	28		36	50.96		48	6.8	216381		39
	29		35	46.56		50	36.8	216516		39
	30		34	42.17		53	7.3	216729		40
	31		33	37.86		55	38.3	217019		40
1891	Jan. 1		32	33.73	+19	58	9.6	217386		41
	2		31	29.83	+20	0	41.1	217831		42
	3		30	26.26		3	12.7	218352		43
	4		29	23.09		5	44.2	218951		44
	5		28	20.40		8	15.7	219624		45
	6		27	18.27		10	47.1	220373		47
	7		26	16.76		13	18.2	221196		48
	8		25	15.96		15	48.9	222093		50
	9		24	15.94		18	19.2	223063		52
	10		23	16.78		20	49.1	224104		54
	11		22	18.55		23	18.5	225216		56
	12		21	21.32		25	47.3	226397	13	58
	13		20	25.14		28	15.5	227646	14	1
	14		19	30.09		30	43.0	228961		3
	15		18	36.23		33	9.8	230341		6
	16	6	17	43.62	+20	35	35.8	0.231785	14	9

New Planetoids Nos. 299 and 300. Planetoid No. 299 was discovered by Palisa, at Vienna, October 6. 4883 Gr. M. T. in R. A. 2^h 16^m 20.8^s, declination north 15° 18′ 25″, magnitude 13th. No. 300 was discovered by Palisa, November 16. 4403 in right accension 3^h 12^m 50.5^s, declination north 10° 14′ 33″. Magnitude 13th. Daily motion westward, 52^s, southward, 3′.

Wolsingham Observatory Circular No. 27. The star D. M. + 33°.470; R. A. 11^h 28^m 16^s, Decl. + 33.° 38′, (1855) Mag. 9.2, was observed on Nov. 7 as 7.5. OR. III Type. The star is probably variable.

T. E. ESPIN.

Nov. 10, 1890.

NOTES AND NEWS.

A very considerable number of subscriptions expire with this number of the MESSENGER. Our friends will oblige us by promptly writing us, if they desire its continuance for the year 1891.

The promptness with which renewals of subscriptions have been made during the last two years, has been an unexpected pleasure to us, especially in view of the increase of price during that period.

Aid for Messenger Illustrations. It will be noticed, by a circular from Professor Pickering, elsewhere given, that the MESSENGER has been very kindly and generously remembered recently, with a considerable gift of money to be used in illustrating its articles. Miss C. W. Bruce, of New York City, is the donor. We are delighted with the company in which she places the MESSENGER in her late benefaction.

James E. Keeler of Lick Observatory visited the Observatory of Carleton College, Northfield, Minn., on his way eastward a few days ago. His stay for two days was a treat for all interested in science. He gave two informal talks while in Northfield; one before the Cosmos Club in the City, on the great Lick Telescope, explaining the three lines of astronomical work it is adapted to do, viz:—Visual observation, photography and spectroscopic observation; and the other before the College Astronomy Class and a company of visitors from one of the high schools of Minneapolis. The aim of the last talk was to give something of the method of work in studying the motions of the nebulæ by the aid of the spectroscope when attached to the great equatorial at Mt. Hamilton. His presentation of this new line of work was so clear and definite that the young people readily understood it, and were enthusiastic in praise of what they heard and the manner of presenting it. He also exhibited his late drawings of the planets Jupiter and Mars, showing the fine surface markings of the former, and some features on the terminator of the latter, as revealed by the great telescope, which we have never seen or known. As specimens of drawings the

pictures were surpassingly excellent. The great red spot, the round white spots, the narrow dark bands veering around the red spot, the elongated circular openings in the great belt, with the deep red color at the bottom of them, were features of absorbing interest in Jupiter's surface markings. On the surface of Mars, the great telescope did not show, at the last opposition, as much as Schiaparelli claims to have seen at other times, and this is what might be expected, for the opposition was not a favorable one for visual study. But, in one of the pictures of Mars, was shown a very remarkable phenomenon which has been spoken of more fully in the planet notes.

Mr. Keeler's visit at Northfield was a source of pleasure and profit that will long be remembered by those who met him.

"*Father Perry Memorial.*" We have noticed, with interest, the movement that has been recently going on to secure a Memorial to the late Stephen Joseph Perry, F. R. S., the distinguished astronomer of Stonyhurst College, England. A short time ago a meeting was held under the presidency of Sir Edward Watkin, Bart., M. P., at which it was judged that such a Memorial would be sure to command general support. It has also been decided that the best mode of perpetuating "Father Perry's" name would be to continue the important astronomical work which he has begun and so well continued for years past. This work at Stonyhurst Observatory has long been hampered by the insufficiency of light supplied by the present 8-inch object glass. It is proposed, therefore, either to procure a new telescope with a 15-inch object glass, or to furnish the present equatorial stand with a 15-inch objective. This would require £2,700 for the complete telescope and house, while £700 would suffice for the objective alone. Whichever plan is carried out, the telescope and the house in which it stands will bear the name of the "Father Perry Memorial," and the work done with it will be published under that name. All persons desiring to subscribe to this worthy object are invited to send their gifts either to the "Father Perry Memorial" account at the London Joint Stock Bank, limited, Pall Mall Branch, London, S. W., or to Arthur Chilton Thomas, Secretary and Treasurer, Marldon Chambers, 30 North John Street, Liverpool, England.

The committee in charge of this undertaking contain the names among others, of the following well known astronomers:—Robert S. Ball, Royal Astronomer, Ireland, W. H. H. Christie, Astronomer Royal, England, A. A. Common; Ralph Copeland, Royal Astronomer for Scotland, Edward S. Holden of Lick Observatory; J. Janssen, of France; J. Norman Lockyer, of England, and C. A. Young, of Princeton.

This worthy enterprise is heartily commended to the attention of the readers of the MESSENGER.

The Western Union Time Service. Comodore Dewey, chief of the equipment bureau of the Navy, makes this statement in his late report

"A most notable feature in the affairs of the bureau in connection with the extensive telegraphic time service, which has become established and apparently indispensable commercial factor centering at the Naval Observ-

atory, has been a concerted attack upon the prevalent system by a large number of observatories located throughout the United States, the object being to break up the system in order that time, which is now furnished without cost from the Naval Observatory, may be distributed and charged for at these minor observatories as a means contributing to their maintenance. It is held by the petitioners that this system should be discontinued by the government to encourage private astronomical institutions of the United States. The subject has been strongly and earnestly presented by the directors of these institutions and detail considerations of a most interesting character enter into the discussion. A recommendation has been made, in view of the great importance of the present system to commerce throughout the country on the one hand, and of the strong case presented by the petitioners on the other hand, that the subject be referred to a commission, which shall broadly represent business and scientific interests, for examination and report."

After somewhat carefully canvassing the matter it seems to us the wise course now to take, is to have this whole matter investigated by a committee from Congress, that the country may know the truth of the unanswered charges that have been preferred.

New Naval Observatory. We notice still further in Commodore Dewey's report, that work on the new Naval Observatory has not progressed satisfactorily from a variety of causes, some natural and unavoidable, and some blameworthy. It is, however, considered probable that the new buildings will be ready for use in the early part of the fiscal year 1891-92.

The Secretary of the Navy has appointed H. E. Damrell, of New York, to be superintendent of construction at the new buildings in the place of Mr. Grant who has held the position since the work began.

Astronomy in Popular Magazines. Almost every month some of the popular magazines contain useful articles on themes from some branch of Astronomy by able scientific writers. We have often reprinted such articles, sometimes made brief extracts from others, and sometimes tried to give abstracts of still other important ones, when space at command was insufficient for fuller notice. This feature has seemed to please many of our readers judging by the favorable letters received, and we now call attention to this point, to ask our readers to do us the favor of notifying us promptly when any worthy article appears in any periodical, that *all* the readers of this magazine may have the benefit of the same.

Astronomical Papers for the American Ephemeris. The irregular intervals at which these papers have appeared leading to frequent inquiries about supposed missing parts, the following statement is issued for the information of recipients:

1. The general plan is to issue the papers in parts, so paged and arranged that they can be bound into a volume of which the paging is continuous. A title page and table of contents accompanies the concluding

part of each volume, thus enabling the completion of the volume to be recognized.

2. The catalogue of 1,098 Standard Clock and Zodiacal Stars forms Part IV of Volume I, which was completely published in 1882, but, unlike the other parts, the separate issues are bound in cloth.

3. Volumes II and III are still incomplete; the fifth part of Volume II is nearly ready, and the concluding (sixth) part of Volume III is now in the printers' hands, but is not likely to be issued before the end of the present year. I hope it will be speedily followed by the concluding part of Volume II.

4. Volume IV is issued complete, and is now in distribution.

S. NEWCOMB,
Superintendent Nautical Almanac.

Motion of the Atmosphere at High Elevation.—In the August number of the SIDEREAL MESSENGER, Professor H. A. Hazen alluded to our scanty knowledge of the direction of motion of the upper strata of our atmosphere, and it may, therefore, not be amiss to describe to your readers a personal observation made on the morning of Nov. 14th, 1867. It will be remembered that this was the time of the occurrence of the latter end of the November 14th star-shower which, on the same date of the previous year, had taken place on the eastern continent. I had observed in all its indescribable glory the great star-shower of 1833, and, inasmuch as its repetition in thirty-three years and one day had been visible in Europe instead of America, I felt quite certain that in just a year quite a shower would appear on the American side of the earth, and made arrangements for its observation. During the display I counted 896 shooting-stars. How many I lost in a cessation of twenty minutes I cannot know. Many were bright and left visible trains in their wake, but only one was seen long enough to determine accurately the direction of its motion. This exploded near the southern limit of Cancer, and disappeared near its northern boundary; its visibility lasted for, at least, twenty minutes. Its changes of form were very numerous and interesting, resembling, at times, several capital letters of the alphabet, sometimes like U, then S, but more frequently like N. Its motion was very slow exactly north, nearly over my zenith. About five minutes before its final disappearance, it centrally transited Præsepe and, while in transit, not a trace of the meteoric *debris* was visible. After gathering itself into a globular mass, it disappeared some 5° or 8° north of Præsepe. I was particularly observant of the direction of its path, having in mind Eccl. 1:6.

It is highly probable that the direction of motion of the upper strata of our atmosphere is somewhat variable, though, judging from the above phenomenon, and also from that of the trade winds, I am of the opinion that north of the equator its direction of motion is generally northward, and, but for the rotatory motion of the earth, would be undeviatingly so.

LEWIS SWIFT.

Warner Observatory, Rochester, N. Y., Nov. 12, 1890.

Aid to Astronomical Research. A circular was issued last summer announcing the gift by Miss Bruce, of six thousand dollars ($6,000) for aiding astronomical research. No restrictions were made upon its expenditure which seemed likely to limit its usefulness, and astronomers of all countries were invited to make application for portions of it, and suggestions as to the best method of using it. Eighty-four replies have been received, and with the advice of the donor the entire sum has been divided so as to aid the following undertakings:—

3. Professor W. W. Payne, Director of the Carleton College Observatory. Illustrations for the Sidereal Messenger.
6. Professor Simon Newcomb, Superintendent of the American Nautical Almanac. Discussion of contact observations of Venus during its transits in 1874 and 1882.
16. Dr. J. Plassmann, Warendorf. For printing observations of meteors and variable stars.
23. Professor H. Bruns, Treasurer of the Astronomische Gesellschaft. To the Astronomische Gesellschaft for the preparation of Tables according to Gylden's method for computing the elements of the asteroids.
27. Professor J. J. Astrand, Director of the Observatory, Bergen, Norway. Tables for solving Kepler's Problem.
29. Professor J. C. Adams, Director of the Cambridge Observatory, England. Spectroscope for the 27-inch telescope of the Cambridge Observatory.
36. Professor A. Hirsch, Secretary of the International Geodetic Association. To send an expedition to the Sandwich Islands to study the annual variation, if any, in latitude.
40. H. H. Turner, Esq., Assistant in Greenwich Observatory. Preparing tables for computing star corrections.
45. Professor Edward S. Holden, Director of the Lick Observatory. Reduction of meridian observations of Struve stars.
46. Professor Lewis Swift, Director of the Warner Observatory. Photographic apparatus for fifteen-inch telescope.
54. Professor Norman Pogson, Director of Madras Observatory. Publication of old observations of variable stars, planets, and asteroids.
57. Dr. Ludwig Struve, Astronomer at Dorpat Observatory. Reduction of observations of occultations during the lunar eclipse of Jan. 28, 1888, collected by the Pulkowa Observatory.
60. Dr. David Gill, Director of the Observatory of the Cape of Good Hope. (1) Reduction of heliometer observations of asteroids. (2) Apparatus for engraving star charts of the Southern Durchmusterung.
78. Professor A. Safarik, Prague. Photometer for measuring variable stars.
79. Professor Henry A. Rowland, Johns Hopkins University. Identification of metals in the solar spectrum.

Of the remaining replies many describe wants no less urgent than those named above. Some relate to meteorology or physics rather than to astronomy, some to work already completed, and others were received too late to be included. Two important cases may be specially mentioned. In each of them an appropriation of a part of the sum required would have been made; but in one, in our own country, an active and honored friend of the science undertakes the whole; and in the other, in France, the generous M. Bischoffsheim, already known as the founder of the great observatory at Nice, ignoring political boundaries and the comparitive selfishness of patriotism, came forward and gave the entire sum required. The same sky overarches us all. It is to be hoped that the above named, and other

foreign institutions, will obtain more important aid from neighbors when these become aware how highly the work of their scientists is appreciated in this country. The replies not enumerated above are confidential, and can not be mentioned except by the permission of the writers. But they have placed me in possession of important information regarding the present needs of astronomers. In several cases a skillful astronomer is attached to a college which has no money for astronomical investigation. He has planned for years a research in the hope that some day he may be able to carry it out. A few hundred dollars would enable him to do this, and he offers to give his own time, taken from his hours of rest, if only he can carry out his cherished plans.

Such valuable results could be attained by the expenditure of a few thousand dollars, that no opportunity should be missed to secure this end. Fortunately, the number of persons in the United States able and willing to give liberally to aid astronomy is very large. It is hoped that some of them may be inclined to consider the case here presented. The income derived from a gift of one hundred thousand dollars would provide every year for several cases like those named above. A few thousand dollars would provide immediately for the most important of the cases now requiring aid. The results of such a gift would be very far reaching, and would be attained without delay. Correspondence is invited with those wishing to aid any department of astronomy, either in large or small sums, by direct gift or by bequest. EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY,
CAMBRIDGE, MASS., U. S. A., *November 11, 1890.*

Black Transit of Jupiter's Third Satellite.—On the evening of July 21, 1890, I observed the most intensely dark transit of a Jovian satellite that it has ever been my fortune to witness. Both satellite III and its shadow were on the face of the planet, the former showing a round disc of dense blackness, its limb sharp and well defined, while the shadow was less black in hue, being brownish in tint, and apparently not exactly circular in form, with definition of the limb somewhat less distinct. As other work demanded my attention, I did not renew the observation to see if it underwent any change of color as it neared the edge of the disc. This general phenomenon I have witnessed before, but never saw the satellite so strikingly black as on this occasion. LEWIS SWIFT.

Duplicity of Jupiter's Southern Equatorial Belt. While showing Jupiter, on August 21 last, to a college professor from Texas, using a power of 132 on the 16 inch refractor, I noted a central and exceedingly narrow division of his southern equatorial belt extending from limb to limb. Powers of 200 and 360 confirmed my suspicions, showing a dividing line of spider-thread fineness, but as bright as the planet's disc. Whether it was simply a luminous line on the belt, that I saw, or its division into two parts, I could not determine, though the separation appeared to be perfect. The line was straight, and, as I now recall it to mind, did not follow the slight sinuosities of the two edges of the belt. The observa-

tion was one of exceeding delicacy, and the phenomenon one that might easily be overlooked, but the gentleman alluded to above, as well as my son Edward, were witnesses with me of this appearance, which I had never before observed, nor do I remember to have read of anything exactly similar. LEWIS SWIFT.

Observations of Jupiter. On Sept. 7 at 9 P. M., Eastern time, Professor C. C. Hutchins, Bowdoin College, Brunswick, Maine, observed two small black spots in the southern limit of the southern great belt of Jupiter, situated a little west of the meridian and at the extremities of a semi-oval area. We have not observed them. Possibly others have seen the same objects.

Notes and News. It has been a constant regret during the past year that it has been so difficult, apparently, to secure a full, fresh table of news and notes of work from the various observatories of this country. Blanks have been sent out with prepaid return envelopes to the number of one hundred a month two or three times during the year, and but few replies in any instance have been received. This has been not only a regret but a surprise, for we know that our readers generally are more interested in this feature of the MESSENGER than in any other, and yet, so far, this important part of our work has received the least general aid. We know it is not beeause the hundreds of astronomers and physicists in the United States have not every week, if not every day, their attention on some interesting and useful phase of our science that would benefit somebody else if put in the proper channel, but for some reason we have failed almost wholly in this particular. Is it the fault of the MESSENGER?

Photographic Notcs. A 13-inch glass prepared by the Brothers Henry for the international work of the photographic survey of the heavens, contributes a photograph of the Ring Nebula in Lyra to a receut number of *Knowledge*. This picture was taken by M. Trépied, the exposure being six hours, made on two successive nights. M. Trépied thinks that in the original negative he has evidence of at least three bright stars in the brighter parts of the ring.

M. Bischoffsheim has given 10,000 francs for a parallactic micrometer for measuring the photographs for the photographic chart of the heavens.

The Observatory for November publishes a note by David Gill on some experiments with the new Cape astro-photographic telescope. A point of interest here brought out is that for stellar photographs, after a certain period of exposure, it is quite immaterial whether the atmospheric definition is good or bad—the photographic images of stars will be equally sharp in either case."

G. M. Searle, in his lecture on "Astronomical Photography as Found in the Photographic Times," calls attention to the photographic method of determining the position of the north pole. For such determination the north polar region is photographed by a stationary telescope—the drive clock not being attached. The stars then form circular trails, having the pole for their common centre.

Velocity of Light. (Abstract of remarks of Henry M. Parkhurst, at the meeting of the Astronomical Department of the Brooklyn Institute, on Oct. 27, 1890.)

If a person riding upon a car should fire a pistol directed forward, the ball would move with the velocity produced by the powder plus the velocity of the car. Is it so with light? It has been supposed, and it would seem to be the correct view, that the motion of light is independent of the body from which it emanates; but I find it laid down in the books that the waves of the ocean, and the waves of sound, move with different velocities; the question arises whether this is also true of the waves of light, and what proof we have that it is not. I quote from standard authorities:

"But several series of waves moving with different velocities may co-exist upon the ocean."—Brande & Cox's Dictionary of Science, Article, Wave.

"It has been observed that an exceedingly loud sound travels faster than a less loud one."—Rodwell's Dictionary of Science, Article, Velocity of Sound.

The difference in the time during which a variable star is diminishing, and the time during which it is increasing, has never been accounted for. Would that be accounted for in any degree by the supposition that the light partakes of the motion of the star? Would such explanation give us an approximation to the distance of the star from the earth?

Assuming, as derived in my paper at our last meeting, that the light rom Mizar takes 150 years to reach the earth, that would produce a difference of 28 days in the time of reaching us, from the opposite sides of the orbit, the period being 104 days. Tracing the light from the different points, I found that it would come to us in a symmetrical way; so that the difference just spoken of would not be at all accounted for. But I reached other peculiar results. The line would double upon itself, so that light would reach us from three different points at once, giving us the double line in the spectrum even if one of the two stars were dark. Again, where the curve doubles upon itself, from the maximum the light would suddenly drop two or three magnitudes, and after a time as suddenly rise to another maximum. Varying the assumption of distance between wide limits I could find no escape from this phenomenon. Yet along all the variable stars, we have no case where there are such changes.

Then I examined the results for Algol, in the same way. Assuming brilliancy corresponding to mass the same as of our sun, the difference of time in the arrival of light would be 1.9 days, the period being 2.8 days. I multiplied this time by 15 and divided it by 15, trying a large variety of distances between these limits. In all these cases I deduced three peculiar results, and found no evidence that they could be avoided so long as light was affected by the motion of the star. 1. The light would be arriving at all times in such a way as to cover the period of occultation; so that Algol would be brighter during the occultation than when the bright star is nearest us. 2. We should see the double lines in the spectrum, notwithstanding the darkness of the companion. 3. We should see the maximum on each side of the aphelion suddenly change to a minimum extending through the perihelion.

I consider the case of Algol as in itself a demonstration that light does not partake of the motion of the body from which it emanates.

Professor D. G. Eaton explained the variation in the velocity of ocean waves by its dependence upon the depth of the ocean, saying that in space no such cause for variation could exist.

Professor P. H. Van der Weyde explained the more rapid motion of loud sounds by supposing the vibration to have been carried more rapidly through the earth for a distance, and being then communicated to the air and taking the form of sound.

NOTE. "The velocity of the wave is accordingly proportional to the square root of the depth of the water, as the theory indicates, and it is not affected by the velocity of the impulse or the form of the body by which it is generated." Brande's Dictionary of Science. Article, Wave. This is omitted in the later edition.

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